Utah Department of Environmental Quality
Division of Solid and Hazardous Waste

Human Health Risk Assessment

Deseret Chemical Depot
Tooele Chemical Agent Disposal Facility (TOCDF)
EPA I.D. No. UT 5210090002

September 2003

Permitting Authority:

State of Utah Department of Environmental Quality
Division of Solid and Hazardous Waste
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APPENDICES

NOTE: All appendices are available from the Division of Solid and Hazardous Waste (DSHW). Appendices B through S are also available in Portable Document Format (PDF) at the DSHW web site http://www.deq.state.ut.us/EQSHW/CDS/CDS_PVA.

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ACRONYMS AND ABBREVIATIONS

ACWA	Assembled Chemicals Weapons Assessment
ADME	Absorption, distribution, metabolism, and excretion
atm	Atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
B(a)P	Benzo(a)pyrene
BCF	Bioconcentration factor
BRA	Brine reduction area
BW	Body weight
CAMDS	Chemical Agent Munitions Disposal System
CDC	Centers for Disease Control and Prevention
CHB	Container handling building
cm	Centimeter
cm^2	Square centimeter
COPC	Compound of potential concern
CSF	Cancer slope factor
DCD	Deseret Chemical Depot
DFS	Deactivation furnace system
DMP	Dimethylphthalate
DNOP	Di-n-octylphthalate
DSHW	Division of Solid and Hazardous Waste
DW	Dry weight
EMS	Ethyl methanesulfonate
FIR	Food ingestion rate
FW	Fresh weight
g	Gram
GB	Isopropyl methylphosphonofluoridate
H	Bis(2-chloroethyl)sulfide
HD	Distilled H
HHRA	Human health risk assessment
HSDB	Hazardous Substance Databank
HI	Hazard index
HQ	Hazard quotient
HT	A mixture of HD and T
HVAC	Heating, ventilation, and air conditioning
IRAP-*h* View	Industrial Risk Assessment Program-Health®
JACADS	Johnson Atoll Chemical Agent Disposal System
K	Kelvin
K_d	Soil-water partitioning coefficient
kg	Kilogram
km	Kilometer
K_{oc}	Soil adsorption coefficient
K_{ow}	Octanol-water partitioning coefficient
L	Liter
LIC	Liquid incinerator
m	Meter
m^3	Cubic meter
MDB	Munitions demilitarization building
MEI	Maximum exposed individual
MF	Metabolism factor

mg	Milligram
mg/kg	Milligram per kilogram
mL	Milliliter
mm Hg	Millimeters of mercury
MPF	Metal parts furnace
MS	Microsoft
MW	Molecular weight
NA	Not applicable
NCDC	National Climatic Data Center
NE	Not evaluated
PAH	Polycyclic aromatic hydrocarbon
PAS	Pollution abatement system
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo(p)dioxin
PCDF	Polychlorinated dibenzofuran
pg	Picogram
pg/kg BW-d	Picogram per kilogram body weight per day
PIC	Product of incomplete combustion
PUB	Process utilities building
RCF	Root concentration factor
RCRA	Resource Conservation and Recovery Act
RfD	Reference dose
s	Second
SAB	Science Advisory Board
SVOC	Semivolatile organic compound
T	Bis-2-(chloroethylthioethyl)ether
TEF	Toxicity equivalence factor
TEQ	Toxicity equivalents
Tetra Tech	Tetra Tech EM Inc.
TIC	Tentatively identified compound
TOCDF	Tooele Chemical Agent Disposal Facility
TOE	Total organic emissions
UDEQ	Utah Department of Environmental Quality
µg	Microgram
µg/m^3	Microgram per cubic meter
USDA	U.S. Department of Agriculture
U.S. EPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound
VX	O-ethyl-S-[2-diisopropylaminoethyl]methylphosphonothiolate
WHO	World Health Organization
yr	Year

Forward

Tetra Tech EM Inc. (Tetra Tech), under Contract No. 006244 with the Utah Department of Environmental Quality, Division of Solid and Hazardous Waste, was issued Work Order 001 to evaluate the potential human exposures to emissions from treatment of chemical munitions at the Tooele Chemical Agent Disposal Facility and the Chemical Agent Munitions Disposal System, which are located at Deseret Chemical Depot in Tooele County, Utah. The Tetra Tech team, led by William Desmond, prepared the protocol and earlier drafts of this health risk assessment. This final draft version of the health risk assessment was prepared by the Division of Solid and Hazardous Waste and incorporates changes in response to public comments and new information that has become available since the last draft was prepared.

1.0 INTRODUCTION

The Utah Department of Environmental Quality (UDEQ) Division of Solid and Hazardous Waste (DSHW) evaluates the potential for adverse health effects that could result from exposure to emissions from treatment of chemical munitions at the Tooele Chemical Agent Disposal Facility (TOCDF) and the Chemical Agent Munitions Disposal System (CAMDS). The TOCDF and CAMDS are located at Deseret Chemical Depot (DCD) in Tooele County, Utah in this human health risk assessment (HHRA). The chemical munitions include two nerve agents and sulfur mustard. The nerve agents are isopropyl methylphosphonofluoridate (GB) and O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate (VX). Sulfur mustard is composed of bis(2-chloroethyl)sulfide (H), HD (distilled H), and HT [a mixture of HD and bis-2-(chloroethylthioethyl)ether (T)]. Small amounts of dimethylphophoramido-cyanidate (GA) and chlorovinyldichloroarsine (Lewisite) are also stored and slated for treatment at DCD.

The specific technical methods, assumptions, and parameters used in the HHRA are presented in the "Final Human Health Risk Assessment Protocol" for DCD (Tetra Tech 2001b). The protocol (1) describes each of the HHRA exposure scenarios evaluated, (2) describes how emission rates for compounds of potential concern (COPC) were determined for each source evaluated, and (3) presents emission rate values for each COPC. COPCs include both detected and non-detected compounds. Deviations from the protocol and changes made in response to public concerns and new information also are discussed in this report.

The objectives of the risk assessment are to calculate the cumulative risks (cancer effects) and hazards (noncancer effects) for each exposure scenario specific to each source at TOCDF and CAMDS and specific to each agent campaign. The DSHW uses risk assessment as a tool for evaluating the protectiveness of hazardous waste operating permits. This risk assessment is an update of the 1996 *Screening Risk Assessment* (A.T. Kearney [ATK}, 1996). Since the release of the *Screening Risk Assessment*, new information, such as emissions testing results, has become available from the TOCDF. This risk assessment was conducted using updated methods recommended by the U.S. Environmental Protection Agency (U.S. EPA).

This HHRA is primarily a prospective risk assessment, that is, this risk assessment evaluates potential future health risks. To evaluate potential future health risks, the HHRA must make assumptions about future conditions such as emission rates and how people might be exposed. In general, the selected assumptions are more likely to overestimate health effects (conservative) than underestimate. The HHRA is a "living document" because the DSHW reevaluates the findings as new information is collected. These re-evaluations may or may not be documented in reports. The reader is advised to contact the DSHW for any current addenda or findings for the HHRA.

Potential adverse health effects were evaluated (1) separately for each source and each agent, and (2) cumulatively to provide a basis for evaluating the protectiveness of the operating conditions in the Resource Conservation and Recovery Act (RCRA) hazardous waste permits for TOCDF and CAMDS. DSHW has the authority and responsibility to establish permit conditions that are protective of human health and the environment (Utah Administrative Code R315-3-3; Title 40 Code of Federal Regulations 270.32(b)(2)).

The HHRA was completed in accordance with the peer review draft of the U.S. Environmental Protection Agency's (U.S. EPA) *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (U.S. EPA 1998), and the errata issued on August 2, 1999 (U.S. EPA 1999). U.S. EPA (1998) was prepared as national guidance to consolidate information presented in other risk assessment guidance and methodology documents previously released by U.S. EPA and state regulatory agencies. U.S. EPA (1998) has been peer reviewed; however, revised guidance has not been issued as of the date of this

HHRA. The latest approved guidance for assessing health risk from RCRA hazardous waste combustors is *Revised Draft Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes* (U.S. EPA 1994). However, U.S. EPA no longer supports the air dispersion model recommended in the 1994 guidance. Therefore, the U.S. EPA Office of Solid Waste recommends the use of U.S. EPA (1998) for conducting human health risk assessments on emissions from RCRA hazardous waste combustion units. Risk calculations were performed with the Industrial Risk Assessment-Health® (IRAP-*h* View) software (Lakes Environmental Software 1998), which calculates risk in accordance with the U.S. EPA (1998) guidance.

Risk characterization output from IRAP-*h* View was imported into a Microsoft Access database, which was queried to identify risk and hazard values to meet the objectives of the risk assessment. The database is available from the DSHW in electronic format as Appendix A. Appendices B through E present revised emission rates for TOCDF and CAMDS. Appendices F through S present electronic IRAP-*h* View output files and Microsoft Access reports in *.pdf format. Adobe Acrobat Reader can be used to open the IRAP-*h* View output files and Access reports. The IRAP-*h* View project files are presented in Appendices T through W.

2.0 SUMMARY OF EMISSIONS FROM TOCDF AND CAMDS

Section 2.0 summarizes information on the sources of air emissions and the methods used to calculate emission rates for COPCs for each source. Detailed information about emission sources, COPCs in emissions, and methods for calculating emission rates for COPCs is presented in the protocol (Tetra Tech 2001b)

The HHRA evaluated six emission sources at TOCDF and four sources at CAMDS. The six sources evaluated at TOCDF include the liquid incinerator (LIC) 1; LIC 2; the metal parts furnace (MPF); the deactivation furnace system (DFS); the brine reduction area (BRA); and the heating, ventilation, and air conditioning (HVAC) system. The four sources evaluated at CAMDS include the MPF, the DFS, the LIC, and the HVAC system. The LIC and MPF at CAMDS share a common stack but do not operate simultaneously. Risks and hazards were calculated for emissions from the MPF only, because the data available for comparing emissions from the LIC and MPF suggest that risks and hazards associated with emissions from the MPF will be higher than those associated with emissions from the LIC. The HVAC at CAMDS has several stacks that were modeled as single point source.

Period of operation may be an important factor because it is used to estimate various terms for characterizing exposure, such as the concentration of COPCs in soil that result from deposition and the concentrations in air used to evaluate the potential for adverse effects from inhalation. As discussed in the protocol, the risk assessment assumed that the agent campaigns at TOCDF would last for a total of 13 years (from 1996 to 2009). For TOCDF, current information indicates that the GB campaign will consume 59 percent (7.67 years) of the total time of operation, the VX campaign will require 19 percent (2.47 years) of the total time, and the sulfur mustard campaign will use 22 percent (2.86 years) of the total time. The TOCDF completed processing of GB munitions in 2002. To evaluate risk associated with treatment of munitions at CAMDS, DSHW estimated a total operating period of 10 years based on available information.

Section 2.1 describes the emission sources at TOCDF. Section 2.2 describes the emission sources at CAMDS. Section 2.3 summarizes the methods and data used to estimate COPC emission rates for each source.

2.1 SOURCES AT TOCDF

The design and operation of TOCDF are based on the Johnston Atoll Chemical Agent Disposal System (JACADS). The demilitarization process at TOCDF involves three major steps: (1) handling and transferring chemical munitions from the Area 10 Storage facility to TOCDF, (2) disassembling and incinerating chemical munitions, and (3) managing the residual waste materials.

Chemical munitions and agents transferred from the Area 10 Storage facility are unloaded at the container handling building (CHB). The munitions and agents are disassembled and incinerated in the munitions demilitarization building (MDB), which contains the four incinerators (LIC 1, LIC 2, MPF, and DFS). The incineration units can, and commonly do, operate simultaneously. The LICs destroy liquid agent drained from munitions and spent decontamination solution. The MPF treats the metal components of the munitions after the bulk of the chemical agent has been removed. The DFS is designed to treat chemical munitions that contain energetic components (propellants, bursters, and explosives) after the bulk of the chemical agent has been removed.

The MDB is maintained under negative pressure by the HVAC system. Process vessels in the pollution abatement system (PAS) building and the process utilities building (PUB) are also maintained under negative pressure. Leaking munitions are not handled in the CHB but the leakers may pass through in sealed containers. Therefore, fugitive emissions (to the atmosphere) from the systems are unlikely to be significant. Potential fugitive emissions were not evaluated separately from the TOCDF HVAC system.

Emissions from each unit are treated by a separate PAS in the PAS building before they are vented to a common stack. PAS brines may be treated in the BRA, but the BRA does not currently operate. The brines are sent off site for treatment and disposal. The BRA, except for the BRA burner and baghouses, is located inside the PUB.

2.2 SOURCES AT CAMDS

CAMDS began operations in September 1979 as a research activity designed to develop methods and procedures—primarily employing various types of incineration—to destroy chemical munitions stockpiled at DCD and other U.S. Army depot locations such as Johnston Atoll, Umatilla Army Depot, and Pine Bluff Arsenal. Since the RCRA Part B permit application was submitted, only the MPF has operated; the LIC and DFS are currently not in operation. CAMDS anticipates that the MPF will be used in the future to destroy (1) off-specification VX-hydrolysate, (2) pretreated ton containers that previously contained lewisite, (3) empty ton containers, and (4) miscellaneous wastes. The MPF may also be used to treat debris from Assembled Chemicals Weapons Assessment (ACWA) support work and debris from ACWA research and development that is generated at CAMDS. Facility personnel have indicated that the LIC, DFS, and MPF will be used in the future to destroy stockpiles of munitions stored at DCD. The HHRA assumes that CAMDS will be used to complete this mission (in other words, it assumes continuous operations).

The demilitarization process at CAMDS involves three major steps: (1) handling and transferring chemical munitions from the Area 10 Storage facility to CAMDS, (2) disassembling and incinerating chemical munitions, and (3) managing waste materials that remain after incineration. At CAMDS, the MPF and LIC are housed within the MPF Building Complex, which also includes the MPF, LIC, Multipurpose Demilitarization Machine, Multipurpose Demilitarization Facility, Bulk Item Facility, Residual Storage Area, and Central Decontamination Supply operations. These structures are all joined and share interior walls. Each area is independently ventilated by ducting that leads to the HVAC filter farm, which is located within the East Utilities Building complex, east of the DFS Building Complex.

The DFS Building Complex is located in a separate building east of the MPF Building Complex. The DFS Building Complex includes the DFS, Unpack Area, Explosive Containment Cubicle, Segregation Area, and Filter 18. Ducting that leads to the HVAC filter farm independently ventilates each area.

The DFS may operate at the same time as either the MPF or LIC, but the MPF and the LIC do not operate at the same time. Because the CAMDS MPF and LIC are not used to treat chemical munitions simultaneously, only the CAMDS MPF was evaluated in the HHRA as being representative of both units. Emissions from the DFS are treated by a separate PAS before they are vented to a separate stack. Emissions from the MPF and LIC are treated by a common PAS before they are vented to a common stack. PAS byproducts (brines) are then collected for off-site disposal. The CAMDS BRA is not in operation and will not be used to treat hazardous waste until a compliance test can be completed to demonstrate the current configuration of the BRA drum dryers and “whirlwet” PAS.

2.3 ESTIMATION OF EMISSION RATES

The COPC emission rates for use in the risk assessment were the best available. The emission rates were calculated based on (1) available trial burn test and test burn data from TOCDF and CAMDS (eight scenarios), or (2) emission rates from trial burn tests for similar units at another facility (CAMDS, TOCDF, or JACADS) when actual trial burn or test burn data were not available (10 scenarios). Available data include results from the trial burn test for the TOCDF GB campaign (all furnaces), the CAMDS MPF GB and VX campaigns, and the CAMDS DFS VX and sulfur mustard campaigns. Test burns are conducted at the beginning of each chemical agent campaign or when significant changes that potentially impact emission rates are encountered. The DSHW reevaluates the findings of the HHRA when new emissions data becomes available.

During the COPC selection process, 393 COPCs were identified. The COPCs include (1) any compounds that had been a target analyte during trial burn tests at TOCDF, CAMDS, or JACADS (detected or nondetected), and (2) any compound that had been reported as a tentatively identified compound (TIC) during trial burn tests at TOCDF, CAMDS, or JACADS. Of these 393 COPCs, 171 were evaluated quantitatively in the risk assessment using either COPC-specific fate, transport, and toxicity data, or surrogate data (primarily for dioxins and polychlorinated biphenyls [PCB] reported as homologue totals). The 122 COPCs that were not evaluated quantitatively include (1) tentatively identified compounds (TIC); (2) volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) that do not have U.S. EPA fate, transport, or toxicity data available. Many of these organic compounds are not components of the waste feed and are not expected as products of incomplete combustion (PIC). (3) Metals that are not typically associated with risk to human health in combustor emissions (aluminum, boron, cobalt, copper, manganese, phosphorus, tin, and vanadium).

Non-detected COPCs may not be present in stack emissions or may be present at some concentration below the detection limit. Assuming that the non-detected COPCs are present at the detection limit ensures that potential risks and hazards for these chemicals are not underestimated and also provides a method of gauging the adequacy of the detection limits.

All of the existing data for TOCDF are relatively current and consistent with current regulations and guidance on collection of trial burn test data for risk assessment. Some of the data for CAMDS (as well as some of the data for JACADS used for extrapolation) are slightly more dated. However, these data sets include reliable information on the emission rates of COPCs that typically affect the outcome of the risk assessment process (that is, dioxins, phthalate esters, PAHs, and mercury). As discussed in Section 4.3.2.1, data on hexavalent chromium are not available for any of the data sets.

COPC-specific emission rates were estimated for the sources evaluated in the risk assessment. Trial burn data for GB were used to calculate emission rates for the sources at TOCDF. Some data were also available from test burns at CAMDS. In the absence of source- and agent-specific emissions data, emission rates were calculated by extrapolation from other facilities and other sources. Table 2-1 summarizes the basis for the source-specific emission rates for each agent campaign, the use of extrapolated data, and COPCs detected for each source.

TABLE 2-1 BASIS OF SOURCE-SPECIFIC EMISSION RATES			
Unit	**Agent**	**Basis of Emission Rates**	**Detected Compounds**
TOCDF			
DFS	VX	• Emission rates (ER) extrapolated from CAMDS DFS VX trial burn data. • Non-detected compounds evaluated at detection limits. • Used TOCDF DFS GB data for PCBs without extrapolation. • TOCDF specific upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, butylbenzylphthalate, di-n-octyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, diethyl phthalate, 3,3'-dichlorobenzidine, 2,4-dichlorophenol • Several dioxin congeners • Barium, cadmium, lead
DFS	GB	• ERs developed from TOCDF GB DFS trial burn data • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, dimethyl phthalate • Total dichlorobiphenyls, total trichlorobiphenyls • Barium, chromium, lead, zinc
DFS	Sulfur Mustard	• ERs extrapolated from JACADS DFS GB trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF specific upset correction factors incorporated into ERs..	• Numerous VOCs, acetophenone, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, dimethyl phthalate, 2,4,6-trichlorophenol • Total trichlorobiphenyls, total tetrachlorobiphenyls • Barium, cadmium, chromium, lead, mercury, nickel, thallium, zinc
MPF	Sulfur Mustard	• ERs extrapolated from JACADS MPF HD trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Methylene chloride • Antimony, arsenic, barium, cadmium, chromium, lead, zinc
MPF	GB	• ERs developed from TOCDF GB MPF trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, bis(2-ethylhexyl)phthalate, dimethyl phthalate, phenanthrene • Several dioxin congeners
MPF	VX	• ERs extrapolated from CAMDS MPF VX trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, naphthalene, phenol • Several dioxin congeners • Antimony, barium, cadmium, lead, mercury, thallium, zinc
LIC 1 and LIC 2	GB	• ERs based on TOCDF GB LIC 1 and LIC 2 trial burn data. • Non-detected compounds evaluated at detection limits. • ERs for metals based on November 1998 metals mini-burn. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, benzoic acid, bis(2-ethylhexyl)phthalate, dimethyl phthalate, phenol • Total TCDD, 2,3,7,8-TCDF • Antimony, barium, cadmium, chromium, lead, mercury, nickel, silver, zinc
LIC 1 and LIC 2	HD	• ERs extrapolated from JACADS LIC HD trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors used incorporated into ERs.	• Numerous VOCs, benzoic acid, benzyl alcohol, dimethyl phthalate • All dioxin congeners • Arsenic, chromium, lead, mercury, selenium, thallium, zinc
LIC 1 and LIC 2	VX	• ERs extrapolated from JACADS LIC VX trial burn data. • Non-detected compounds evaluated at detection limits. • TOCDF-specific upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, dimethyl phthalate, 2-methylphenol, 4-methylphenol, naphthalene • One dioxin homologue • Barium, chromium, zinc
BRA	NA	• ERs developed from TOCDF BRA trial burn data. • TOCDF-specific upset correction factors incorporated into ERs.	• Barium, cadmium, chromium, lead, nickel, silver, zinc
HVAC	GB, VX, and Sulfur Mustard	• Based on 20 percent of agent 8-hour time weighted average and maximum stack gas flow rate. • TOCDF-specific upset correction factors used.	Not applicable

TABLE 2-1 (Continued) BASIS OF SOURCE-SPECIFIC EMISSION RATES			
Unit	**Agent**	**Basis of Emission Rates**	**Detected Compounds**
CAMDS			
DFS	Sulfur Mustard	• ERs developed from CAMDS DFS sulfur mustard trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate • Several dioxin homologues • Arsenic, barium, cadmium, chromium, lead, mercury, nickel, silver
DFS	VX	• ERs developed from CAMDS DFS VX trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, butylbenzylphthalate, di-n-octyl phthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, diethyl phthalate, 3,3'-dichlorobenzidine, 2,4-dichlorophenol • Several dioxin homologues • Barium, cadmium, lead
DFS	GB	• ERs extrapolated from TOCDF DFS GB trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, acetophenone, dimethyl phthalate • Barium, chromium, lead, zinc
MPF	GB	• ERs developed from CAMDS MPF GB trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Numerous VOCs, benzoic acid, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, phenol • Several dioxin congeners • Arsenic, chromium, lead, selenium, silver
MPF	VX	• ERs developed from CAMDS MPF VX trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, dimethyl phthalate, 2,4-dinitrotoluene, 2,6-dinitrotoluene, naphthalene, phenol • Several dioxin congeners • Antimony, barium, cadmium, lead, mercury, thallium, zinc
MPF	Sulfur Mustard	• ERs extrapolated from JACADS MPF sulfur mustard trial burn data. • Non-detected compounds evaluated at detection limits. • Default upset correction factors incorporated into ERs.	• Methylene chloride • Antimony, arsenic, barium, cadmium, chromium, lead, zinc
HVAC	GB, VX, and Sulfur Mustard	• ERs set equal to 20 percent of agent 8-hour time weighted average and maximum stack gas flow rate.	Not applicable

Notes:

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace
GB	Isopropyl methylphosphonofluoridate
HVAC	Heating, ventilation, and air conditioning filter system
JACADS	Johnston Atoll Chemical Agent Disposal System
LIC	Liquid incinerator
MPF	Metal parts furnace
PCB	Polychlorinated biphenyl
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diiospropylaminoethyl]-methyl phosphonothiolate

3.0 EXPOSURE ASSESSMENT

The protocol describes the exposure setting, the exposure scenarios, and the mathematical procedures, assumptions, and U.S. EPA-recommended (or “default”) parameters used to quantify exposure. Sections 3.1 and 3.2 summarize the exposure setting and the exposure scenarios evaluated. Section 3.3 presents the site-specific fate, transport, and exposure parameter values used in the HHRA, including parameters that deviate from the protocol, are not reported in the protocol, or deviate from U.S. EPA default values. Sections 3.4 through 3.8 discuss procedures used to specifically evaluate PCBs, dioxins, lead, chromium, and mercury. These sections discuss (1) the specific procedures used to evaluate these compounds, and (2) the limitations associated with the available emissions data.

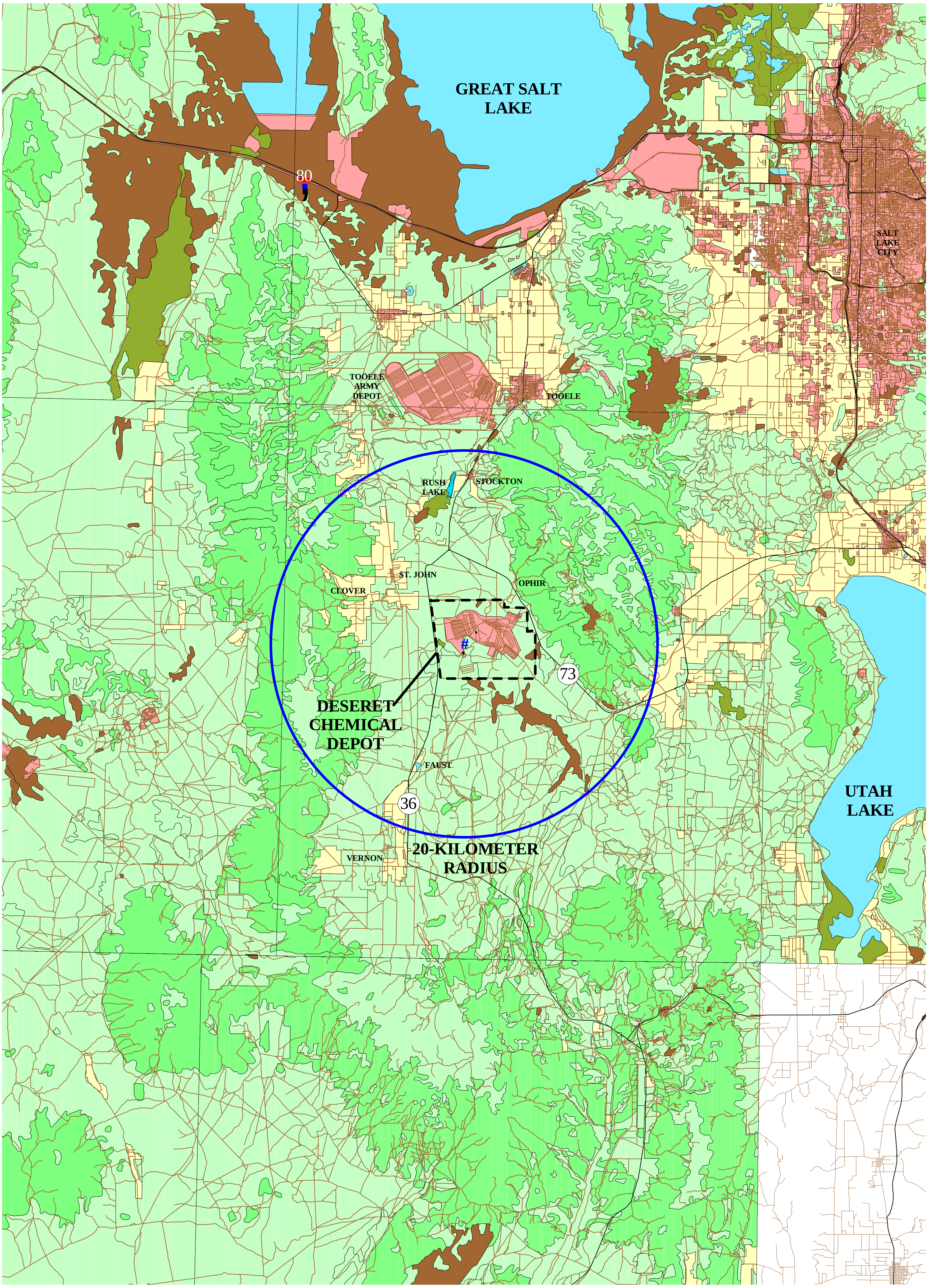
3.1 EXPOSURE SETTING

DCD is a 19,400-acre facility located in the rural, moderately flat and semi-arid Rush Valley in Tooele County, Utah. Rush Valley is surrounded by Tooele Valley to the north, the Oquirrh Mountains to the east, the West Tintic and Sheeprock Mountains to the south, and the Stansbury and Onaqui Mountains to the west (Figure 3-1). DCD is 50 miles southwest of Salt Lake City, 20 miles south of the City of Tooele and the Tooele Army Depot, and 38 miles northwest of the City of Provo. The largest towns inside the 20 kilometer (km) radius assessment area include Faust, Clover, St. John, Ophir, and Stockton. The main types of land use include agricultural areas, forested areas in the mountains east and west of the facility, and rangeland. The closest domicile is approximately 3 km from the DCD fenceline.

Four water bodies were evaluated in the risk assessment: Soldier Creek, Rush Lake, the SunTen water ski ponds, and Rainbow Reservoir. Soldier Creek, which may flow into Rush Lake during spring snowmelt, is the source of drinking water for the town of Stockton. The drinking water pathway was evaluated for the subsistence rancher and resident scenarios. Fishing and incidental ingestion of water were evaluated for Rush Lake. Incidental ingestion of water was also evaluated for the SunTen water skier scenario; the ponds are several kilometers west of the facility. Ingestion of fish was evaluated for Rainbow Reservoir, a small pond in the northeast corner of the DCD grounds that may be open to the public for recreational fishing (see Figure 3-2).

Special subpopulations were qualitatively evaluated in the risk assessment. Special subpopulations include schools, hospitals, nursing homes, and daycare facilities. On July 20, 2001, the yellow pages at http://yp.yahoo.com was searched for names and locations of special subpopulations using keywords for each of the five towns in the study area listed above. Based on the listings in the Yahoo yellow pages, there are no special subpopulations in the assessment area (20-km radius from DCD). The nearest subpopulations are as follows:

- The nearest school is Cedar Valley Elementary School in the town of Cedar Valley, 25 km east-northeast of DCD (measured from the center of the facility).
- The nearest hospital is Tooele County Hospital in Tooele, 25 km north of DCD.
- The nearest nursing home is Tooele Valley Nursing Home in Tooele, 25 km north of DCD.
- The nearest day care listed is South Valley Care Center in West Jordan, about 40 km northeast of DCD.



LEGEND

LAND USE CLASSIFICATION
- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- MIXED RANGELAND
- WATER
- WETLAND

DESERET CHEMICAL DEPOT BOUNDARY

CENTRIC POINT FOR ATMOSPHERIC DISPERSION MODELING

36 STATE HIGHWAY

INTERSTATE HIGHWAY

NOTES: 20-KILOMETER RADIUS IS FROM A POINT CENTERED ON THE TOCDF AND CAMDS FACILITIES.
GRID IS BASED ON THE NORTH AMERICAN DATUM 1927 1000-METER UNIVERSAL TRANSVERSE MERCATOR COORDINATE SYSTEM.
LAND USE CLASSIFICATION FOR THE LOWER RIGHT CORNER OF THE MAP COULD NOT BE DISPLAYED DUE TO A FILE ERROR.

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

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W E
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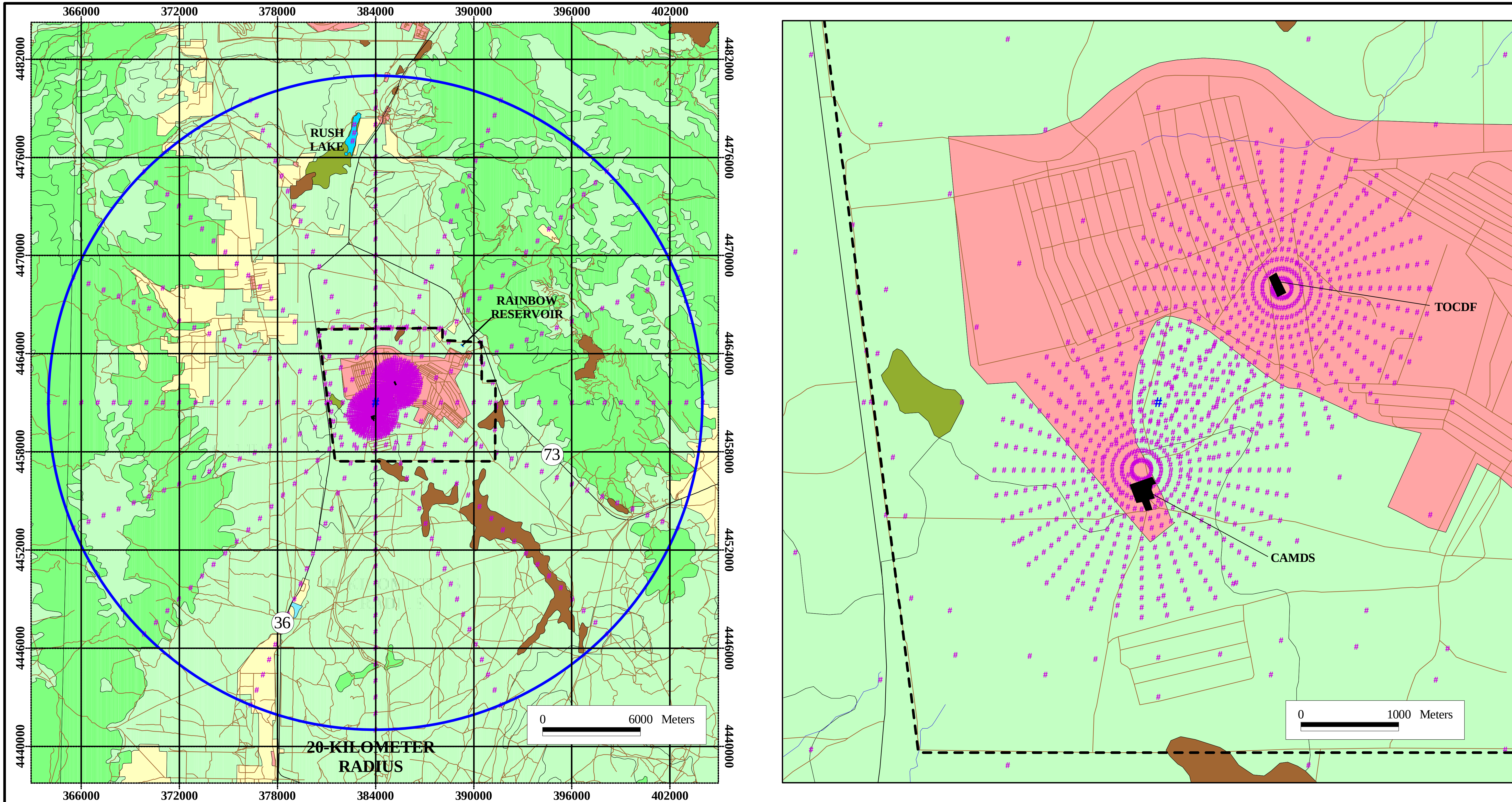
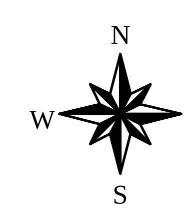
10 0 10 Kilometers

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 3-1
SITE LOCATION MAP

TETRA TECH EM INC.





NOTES: 20-KILOMETER RADUS IS FROM A POINT CENTERED ON THE TOCDF AND CAMDS FACILITIES.
GRID IS BASED ON THE NORTH AMERICAN DATUM 1927 1000-METER UNIVERSAL TRANSVERSE MERCATOR COORDINATE SYSTEM.
CAMDS = CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM
TOCDF = TOOELE CHEMICAL AGENT DISPOSAL FACILITY

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

LEGEND

LAND USE CLASSIFICATION
- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- MIXED RANGELAND
- WATER
- WETLAND

DESERET CHEMICAL DEPOT BOUNDARY

COORDINATE SYSTEM USED FOR AIR DISPERSION MODELING

36 STATE HIGHWAY

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 3-2
LAND USE AND LAND COVER MAP

TETRA TECH EM INC.

The locations of the on-site and off-site receptor locations evaluated in the air dispersion modeling are shown on Figure 3-2. A receptor location is an X,Y (longitude, latitude) coordinate for which the air dispersion modeling calculates the concentrations of COPCs in air (vapor, particle, and particle-bound) and the deposition rate for each COPC. The HHRA protectively evaluated the "maximum exposed individual" (MEI), which is the receptor location (specific to each exposure scenario) that presents the highest risk or hazard value for each exposure scenario evaluated. The MEI location does not necessarily correspond to a particular land use or exposure scenario. The receptor location with the maximum off-site point of impact (specific to each exposure scenario) was used to assess risk and hazard to all off-site receptors, which ensured that the risk assessment considered the potential risks to human receptors that may populate all off-site areas. Likewise, the receptor location with the maximum on-site point of impact was used to assess risk and hazard for the DCD on-site worker scenario to ensure that all on-site workers were considered in the risk assessment. The protocol describes how the maximum points of impact were identified.

3.2 EXPOSURE SCENARIOS

The risk assessment evaluated exposure scenarios for: (1) the subsistence rancher adult and child, (2) the resident adult and child, (3) the on-site DCD worker, (4) the recreationist adult and child (for both the SunTen water ski lakes and Rush Lake), and (5) the fisher adult and child (for Rainbow Reservoir). As discussed in the protocol, the risk assessment evaluated all exposure pathways recommended by U.S. EPA (1998), as follows:

- Inhalation (acute risk) was evaluated as a current exposure for the resident adult and child, on-site DCD worker, and the subsistence rancher adult and child.

- Incidental ingestion of soil was evaluated as a current exposure for the resident adult and child and the on-site DCD worker.

- Ingestion of drinking water from surface water sources (Soldier Creek) was evaluated as a current exposure for the resident adult and child and the subsistence rancher adult and child.

- Incidental ingestion of surface water (Rush Lake) was evaluated as a current exposure for the recreationist adult and child.

- Ingestion of homegrown produce and home-produced beef, sheep, poultry, and eggs was evaluated as a current exposure for the subsistence rancher adult and child.

- Ingestion of home-produced cow's milk and pork was evaluated as a potential future exposure for the subsistence rancher adult and child.

- Ingestion of fish (Rush Lake) was evaluated as a potential future exposure for the recreational adult and child.

- Ingestion of dioxins in breast milk by an infant of a resident, subsistence rancher, and on-site worker was evaluated as a current exposure.

- Ingestion of home-produced goat's milk (as a potential future exposure) for the subsistence rancher adult and child

- Ingestion of fish from Rainbow Reservoir for the fisher adult and child (evaluated as a current scenario)

- Incidental ingestion of surface water at SunTen water ski lakes for the recreationist adult and child (evaluated as a current scenario)

The risk assessment also evaluated the combined risk to a rancher adult who is also an on-site worker at DCD.

3.3 FATE, TRANSPORT, AND EXPOSURE PARAMETERS

COPCs were identified using U.S. EPA (1998) procedures from among the chemicals analyzed in trial burn tests. The exposure assessment used fate and transport parameter values recommend in U.S. EPA (1998). These parameter values are presented in the protocol. Section 3.3.1 presents the parameters for the agents. Section 3.3.2 presents the exposure parameters used to evaluate ingestion of mutton and goat's milk. Section 3.3.3 presents the site-specific climatic and water body information used in the HHRA.

3.3.1 Parameter Values for GB, VX, and Sulfur Mustard

The fate, transport, and toxicity of GB, VX, and sulfur mustard were quantitatively evaluated with parameter values available in the TOCDF *Screening Risk Assessment* (ATK, 1996) and from the National Library of Medicine Hazardous Substances Data Bank available on-line at http://toxnet.nlm.nih.gov/. In addition, some parameter values were calculated using equations available in U.S. EPA (1998). The parameter values are listed in Table 3-1.

3.3.2 Evaluation of Mutton and Goat's Milk Pathways for the Subsistence Rancher

The mutton and goat's milk pathways for the subsistence rancher were quantitatively evaluated using food and media ingestion rates (for the sheep and goats) identified from available sources. Concentrations of COPCs in mutton and goat's milk were calculated by substituting food and media ingestion rates for sheep and goats for the corresponding values in the equations for beef cattle (Equation 5-22 in U.S. EPA 1998) and cow's milk (Equation 5-24 in U.S. EPA 1998). Default COPC biotransfer factors for beef and cow's milk were assumed to be representative for mutton and goat's milk. Sections 3.3.2.1 and 3.3.2.2 discuss the procedures used to estimate food and media ingestion rates for sheep and goats.

One U.S. EPA default pathway is ingestion by the subsistence rancher of home-produced meat (beef, poultry, and pork), eggs, and cow's milk. Exposures from ingestion of mutton and goat's milk was not added to the exposures from the U.S. EPA default scenarios because the addition would exceed the total quantity of meat and diary products that a receptor might consume, over counting the potential exposures. The exposure factors for the U.S. EPA default scenarios would require modification to alleviate this violation. Therefore, the mutton and goat's milk pathways were evaluated separately to ensure that the risk assessment is consistent with U.S. EPA-recommended exposure factors for ingestion of beef, poultry, pork, eggs, and cow's milk.

3.3.2.1 Ingestion of Mutton

To estimate a food ingestion rate for sheep, it was assumed that sheep consume equal parts of forage, silage, and grain. According to the U.S. Department of Agriculture (USDA [2000]), the average live weight of sheep slaughtered in the U.S. in 1999 was 60.33 kilograms (kg).

TABLE 3-1 FATE, TRANSPORT, AND TOXICITY PARAMETERS FOR GB, VX, AND SULFER MUSTARD				
Parameter	**Units**	**GB**	**VX**	**Sulfur Mustard**
Molecular weight (MW)	g/mole	140.09	267.37	159.07
Melting point of chemical (T_m)	K	216.15	323.15	286.5
Vapor pressure (Vp)	atm	2.9	7.0E-04	0.09
Solubility (S)	mg/L	0	3.0E+04	0.684
Henry's Law constant (H)	atm-m^3/mole	4.9E-07	2.4E-10	2.2E-05
Diffusivity of COPC in air (D_a)	cm^2/s	0.0693	0.0449	0.0636
Diffusivity of COPC in water (D_w)	cm^2/s	8.03E-06	5.2E-06	7.37E-06
Octanol-water partition coefficient (K_{ow})	Unitless	5.25	123.03	23.44
Soil organic carbon-water partition coefficient (K_{oc})	mL water/g soil	5.159	60.423	16.581
Soil-water partition coefficient (Kd_s)	cm^3 water/g soil	3.2E-02	7.6E-01	1.41E-01
Suspended sediments-surface water partition coefficient (Kd_{sw})	L water/kg suspended sediment	2.4E-01	5.7	1.1
Bed sediment/sediment pore water partition coefficient (Kd_{bs})	cm^3 water/g bottom sediment	1.3E-01	3.0	5.8E-01
COPC loss constant caused by abiotic and biotic degradation (ksg)	Yr^{-1}	NA	NA	NA
Fraction of COPC air concentration in vapor phase (F_v)	Unitless	1.0	1.0	1
Root concentration factor (RCF)	µg COPC/g DW plant)/ µg COPC/mL soil water)	9.3E-01	2.1	1.2
Plant-soil bioconcentration factor for COPC in belowground produce ($Br_{rootveg}$)	Unitless	29.06	2.76	8.57
Plant-soil bioconcentration factor for COPC in aboveground produce ($Br_{leafyveg}$)	Unitless	14.85	2.4	6.25
Plant-soil bioconcentration factor for forage (Br_{forage})	Unitless	14.85	2.4	6.25
COPC air-to-plant biotransfer for aboveground produce ($Bv_{leafyveg}$)	Unitless	1.7	9.9E+04	1.8E-01
COPC air-to-plant biotransfer factor for forage (Bv_{forage})	Unitless	1.7	9.9E+04	1.8E-01
Biotransfer factor for milk (Ba_{milk})	day/kg FW tissue	4.2E-08	9.8E-07	1.9E-07
Biotranfer factor for beef (Ba_{beef})	day/kg FW tissue	1.3E-07	3.1E-06	5.9E-07
Biotransfer factor for pork (Ba_{pork})	day/kg FW tissue	1.56E-07	3.72E-06	7.08E-07
Bioconcentration factor for fish (BCF_{fish})	Unitless	1.4	18	4.8
Bioaccumulation factor for fish (BAF_{fish})	L/kg FW tissue	1.4	18	4.8
Biota-to-sediment accumulation factor ($BSAF_{fish}$)	Unitless	1.4	18	4.8
Reference dose (RfD)	mg/kg day	9.3E-06	9.3E-06	1.5E-07
Oral cancer slope factor (Oral CSF)	(mg/kg day)$^{-1}$	NA	NA	7.7
Reference concentration (RfC)	mg/m^3	3.0E-06	3.0E-06	1.0E-04
Inhalation unit risk factor (URF_{inh})	(µg/m^3)$^{-1}$	NA	NA	2.7E-03
Inhalation cancer slope factor (Inhalation CSF)	(mg/kg day)$^{-1}$	NA	NA	7.9
Plant-soil bioconcentration factor for COPC in grain (Br_{grain})	Unitless	14.85	2.4	6.25
Biotransfer factor for eggs (Ba_{egg})	day/kg FW tissue	4.17E-05	9.77E-04	1.86E-04
Biotransfer factor for chicken ($Ba_{chicken}$)	day/kg FW tissue	1.04E-07	2.48E-06	4.72E-07
Inhalation reference dose (Inhalation RfD)	mg/kg day	3.0E-05	9.0E-08	9.0E-08

Notes:

atm	Atmospheres	L	Liter
cm	Centimeter	M	Meter
COPC	Compound of potential concern	µg	Microgram
DW	Dry weight	mg	Milligram
FW	Fresh weight	mL	Milliliter
g	Gram	NA	Not applicable
GB	Isopropyl methylphosphonofluoridate	S	Second
K	Kelvin	VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate
kg	Kilogram	yr	Year

This body weight was used as the input into an allometric equation for calculating the food ingestion rate for an herbivorous mammal (U.S. EPA 1993):

$$0.577 \text{ x } BW^{0.727} = FIR$$

where, BW = Body weight (kg)
FIR = Food ingestion rate (kg dry weight [DW] per day [d])

Based on a body weight of 60.33 kg, the food ingestion rate for sheep is 1.724 kg DW/d, which was partitioned equally among forage, silage, and grain (0.575 g DW/d per food item). A sheep's soil ingestion rate was estimated based on the fraction (4.3 percent) of soil ingested by beef cattle (U.S. EPA 1998). Based on a value of 4.3 percent soil in the diet, the soil ingestion rate for a sheep is 0.0732 kg DW/d. A rate for the ingestion of mutton by the subsistence rancher was set at 1.3 g DW/d for adults (National Livestock and Meat Board 1993) and 0.08 g DW/d for children (U.S. EPA 1989).

3.3.2.2 Ingestion of Goat's Milk

To estimate a food ingestion rate for a goat, it was assumed that the animal feeds on forage only. According to the American Dairy Goat Association (Tetra Tech 2001a), 150 pounds (68.04 kg) is the minimum weight for a dairy goat to be entered into competition. It was assumed that this value is representative for a dairy goat owned by a subsistence rancher. This body weight was used as the input into the allometric equation presented above to calculate a food ingestion rate for an herbivorous mammal. Based on a body weight of 68.04 kg, the goat food (forage) ingestion rate is 1.882 kg DW/d. The goat's soil ingestion rate was estimated based on the fraction (4.3 percent) of soil ingested by beef cattle (U.S. EPA 1998). Based on a value of 4.3 percent soil in the diet of a goat, a soil ingestion rate equal to 0.081 kg DW/d was calculated.

To estimate exposure by ingestion of goat's milk, it was assumed that the subsistence rancher entirely replaces cow's milk intake with goat's milk. Intake of goat's milk, therefore, was assumed to be the same as the default value for the ingestion of cow's milk reported by U.S. EPA (1998).

3.3.3 Climatic and Water Body Information

Information on climate and water bodies was collected to evaluate exposure pathways for four water bodies around DCD. Table 3-2 lists the site-specific climatic parameters, and Table 3-3 lists the parameters specific to each water body evaluated in the HHRA.

Watershed area is used to estimate concentrations of COPCs in the water column, bed sediment, fish, and other sinks. The effective area of each watershed was estimated in accordance with U.S. EPA (1998) guidance. The size of the effective watershed area was evaluated based on the exposure scenarios for corresponding water bodies. A small watershed was calculated for Rainbow Reservoir since surface flow into the reservoir is expected to be negligible. Soldier Creek supplies the drinking water for Stockton. The intake structure for the raw water (collected during spring snow melt) is situated in the Oquirrh Mountains east of the city. Therefore, the effective watershed based on the drainage area for the intake structure was estimated from topographic contours. The SunTen water ski pond is fed by springs. Therefore, a minimal watershed around the perimeter of the pond was estimated to account for surface water input during rain. The effective watershed for Rush Lake included the lake and the wetlands area northeast of the lake.

TABLE 3-2 SITE-SPECIFIC CLIMATIC PARAMETERS			
Parameter	**Units**	**Value**	**Reference**
Annual Precipitation	cm/yr	27.25[a]	NCDC 2000
Average Annual Irrigation	cm/yr	75[b]	Baes and others 1984
Surface Water Runoff	cm/yr	1.27	Geraghty and others 1973
Evapotranspiration	cm/yr	29.6	Water Resources Work Group 1986
Wind Velocity	m/s	4.15[c]	MRI 1999

Notes:

a Average of annual precipitation values from 1954 to 1997. Data for 1955, 1963, 1965 through 1971, 1974, and 1990 are missing.
b Value taken from a range reported in the reference cited.
c Average wind velocity for Salt Lake City, Utah, from 1986 through 1990.
cm/yr Centimeter per year
MRI Midwest Research Institute
NCDC National Climatic Data Center

TABLE 3-3 WATER BODY PARAMETERS			
Parameter	**Units**	**Value**	**Reference**
All watersheds			
USLE cover management factor	Unitless	0.1	U.S. EPA 1994
USLE rainfall factor	yr^{-1}	50	U.S. EPA 1994
Rush Lake			
Depth of water column	M	2	UDEQ 1995
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	0	Best Professional Judgment [a]
Rainbow Reservoir			
Depth of water column	M	4.6	Tetra Tech 2000
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	1,392,728.5	Tetra Tech 2000
Soldier Creek			
Depth of water column	M	1	Tetra Tech 2000
Current velocity	m/s	1	Tetra Tech 2000
Average volumetric flow rate	m^3/yr	320,022	Tetra Tech 2000
SunTen Ponds			
Depth of water column	M	1.2	Tetra Tech 2000
Current velocity	m/s	0	Best Professional Judgment [a]
Average volumetric flow rate	m^3/yr	0	Best Professional Judgment [a]

Notes:

a The lakes and reservoir have no surface output. Therefore, based on best professional judgment, velocity and volumetric flow rate were set to zero.
m^3/yr Cubic meter per year
m/s Meter per second
m Meter

3.3.4 Modifications in the Procedures for the Risk Assessment

The results of the risk calculations and evaluation of public comments received indicated that revisions to the risk assessment procedures (Tetra Tech 2001b) were warranted. Complete public comments and responses are in Appendix X. Changes to the risk assessment procedures are as follows:

- **Estimation of Risk and Hazard**. The protocol proposed to provide a single estimate of risks and hazards based on COPCs that were detected and COPCs that were not detected in stack emissions (all COPCs). As discussed in Section 4.1, the methodology was revised for TOCDF so that an additional risk and hazard estimate was calculated for detected COPCs only (in addition to the estimate for all COPCs). The procedure was not used for estimating risks and hazards from CAMDS or for the combined emissions of CAMDS and TOCDF because of difficulties in applying the detect-nondetect concept to the available emission rates. For instance, if a COPC was detected during GB trial burns but not during VX trial burns, should the COPC be evaluated as a detect for the combined emissions?

- **Extrapolation of Ingestion Cancer Slope Factor for Chromium**. The inhalation cancer slope factor for hexavalent chromium was not extrapolated to an ingestion cancer slope factor as recommended by U.S. EPA (1998). Hexavalent chromium was not evaluated as an oral carcinogen because none of the available data suggests that hexavalent chromium is carcinogenic via the oral route of exposure (IRIS, 2003). All ingested chromium was assumed to be non-carcinogenic.

- **COPC Emission Rates**. The values for several emission rates were updated to address minor calculation and classification errors. The changes had no significant effect on the magnitude of the risk and hazard estimates reported in the draft risk assessment report (that is, COPCs with risks and hazards reported above reporting levels in the draft risk assessment report still exceed the reporting levels). The revised emission rates are presented in Appendix B.

- **Evaluation of Cumulative Risks and Hazards for TOCDF**. The simple addition of unit-specific risks and hazards for each agent campaign at TOCDF resulted in a vast overestimation of cumulative risks and hazards (Section 4.2.4). Therefore, weighted-average, unit-specific emission rates were used to assess cumulative risks and hazards associated with emissions at TOCDF. Emission rates were weighted based on the duration of each agent campaign compared with the total duration of all campaigns. The weighting procedure and the weighted-average emission rates are presented in Appendix C. CAMDS emissions were worst-case for each COPC.

- **Sulfur Mustard Campaign Emission Rates for the CAMDS DFS**. Two sets of emission rates were available to estimate the risks and hazards associated with the CAMDS DFS. For the draft final report, a single set of emission rates was created from the highest COPC-specific emission rates listed in the two sets. The revised set of emission rates is presented in Appendix D.

- **Evaluation of Risks and Hazards for CAMDS**. The draft risk assessment evaluated agent-specific risks and hazards for each unit at CAMDS. The unit-specific risks and hazards for each agent campaign were summed to estimate cumulative risks and hazards. However, this method overestimated cumulative risks and hazards by several orders of magnitude. Therefore, unit-specific cumulative risks and hazards were evaluated using the highest, or worst-case, emission rates among the three campaigns. GB, VX, and mustard were conservatively assumed to be emitted simultaneously. The set of worst-case CAMDS emission rates is presented in Appendix D.

- **Dioxin TEFs**. In the draft HHRA, the dioxin TEFs for three congeners were not the most current values recommended by U.S. EPA. The revision in TEFs had no effect on the conclusions for dioxin risks.

- **Acute inhalation hazards for GB and VX.** Acute inhalation hazards were evaluated using the recently released airborne exposure guideline levels (AEGLS) for GB and VX. These AEGLs were not available for the previous draft of the HHRA. No acute inhalation hazard is predicted for GB or VX.

- **Potential GB emissions during the TOCDF VX campaign.** GB was added as a COPC for the TOCDF VX campaign. GB was added because TOCDF plans to process GB secondary waste during the VX campaign. GB was assumed to be emitted at the same concentrations assumed for the GB campaign. The conclusions for the VX campaign are unchanged.

- **Upsets.** Two more years of data was evaluated for determining the frequency of upset conditions at TOCDF. Upsets occur at a similar frequency for the three years (1998, 1999, and 2000) of data.

- **Text clarifications**. Details were added and the text revised for clarity in response to public comments.

In addition to modifications to emission rates, several exposure parameters differ from the values listed in the protocol or are not reported in the protocol.

- The inhalation exposure durations for the resident adult and child, subsistence rancher adult and child, and the on-site worker correspond, for each agent campaign, to the agent-specific periods of combustion, which are 7.67 years for GB, 2.47 years for VX, and 2.86 years for sulfur mustard

- The average depth of Rush Lake was corrected from six meters to two meters.

- The DCD worker exposure frequency was changed from the default of 2,000 hours per year to 4,000 hours per year to ensure potential exposures for emergency personnel who may work 24 hour shifts were not underestimated.

3.4 EVALUATION OF POLYCHLORINATED BIPHENYLS

PCBs were evaluated in the risk assessment using two different approaches (U.S. EPA, 1998). First, to calculate the risk and hazard of all PCB congeners, total PCBs were modeled as Aroclor 1254 using a slope factor of 2 milligrams per kilogram-day because the sampling data indicated that the mixture of PCBs in the stack gas emissions contained 0.5 percent or more PCB congeners with more than four chlorine atoms (between 39 and 52 percent). U.S. EPA recommends that the fate and transport properties for Aroclor 1254 be used for modeling this type of PCB mixture because approximately 77 percent of Aroclor 1254 is composed of PCB congeners with more than four chlorine atoms.

Second, a PCB toxicity equivalence (TEQ) value was calculated for the dioxin-like coplanar PCB congeners, using the list of dioxin-like coplanar PCB congeners and toxicity equivalence factors (TEF) presented in U.S. EPA (1998) guidance. Fate and transport of the PCB TEQ was modeled based on Aroclor 1254 to calculate the average daily dose value. The slope factor for 2,3,7,8-TCDD was applied to the daily dose to estimate cancer risk from coplanar PCBs.

A summary of the PCB emission rates, TEF values, and TEQ values is presented in Appendix E. The U.S. EPA (1998) list of dioxin-like coplanar PCB congeners and the available trial burn test data are based on a 1994 World Health Organization (WHO) list of dioxin-like coplanar PCB congeners and TEF values (Ahlborg and others 1994). In 1997, WHO revised its list of dioxin-like coplanar PCB congeners and TEF values, adding one congener (3,4,4',5-tetrachlorobiphenyl), deleting two congeners (2,2',3,3',4,4',5-heptachlorobiphenyl and 2,2',3,4,4',5,5'-heptachlorobiphenyl), and decreasing (by a factor of 5) the TEF value for one congener (3,3',4,4'-tetrachlorobiphenyl) (Van den Berg and others 1998). For informational purposes, both the 1994 and 1997 WHO values are presented in Appendix E. Because all of the emission rate values for the dioxin-like coplanar PCB congeners are based on concentrations in samples of stack gas reported at the detection limits (non-detected), the differences in congeners and TEF values are not expected to significantly alter the results of the risk assessment.

3.5 EVALUATION OF DIOXINS

For this report, polychlorinated dibenzo(p)dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are collectively described as “dioxins.” Dioxins can be formed during the incineration process. Dioxins with chlorine atoms in the 2, 3, 7, and 8 positions are highly toxic and persistent in the environment. After being released to the environment, dioxins accumulate in food products such as beef and milk (primarily in the fat). Dioxins are suspected to cause cancer. Dioxins also may cause noncancer effects such as reproductive and developmental effects, immunotoxicity, and wasting syndrome (U.S. EPA 2000). Exposure to dioxins has been associated with an increased incidence of diabetes.

The U.S. EPA Office of Solid Waste and Emergency Response recommends that dioxins be evaluated for carcinogenic effects only because of the lack of an appropriate consensus noncancer toxicity value (for instance, reference dose) for dioxins. Potential carcinogenic risks from exposure to dioxins were evaluated according to U.S. EPA (1998) guidance based on the current slope factor for 2,3,7,8-tetrachlorodibenzo(p)dioxin (TCDD) of 1.5E+05 mg/kg-day^{-1}. In September 2000, the U.S. EPA Science Advisory Board (SAB) recommended a new slope factor of 1.0E+06 (mg/kg-day)$^{-1}$ for evaluating the cancer potency of dioxins (U.S. EPA 2000). Dioxin risks based on the proposed slope factor were also evaluated.

3.6 EVALUATION OF LEAD

U.S. EPA has not recommended a reference concentration or reference dose to evaluate the hazard of lead. Neurobehavioral effects of lead have been observed in children with blood lead levels below those that have caused cancer in laboratory animals. For various reasons, children are more susceptible to exposures to lead than adults. Therefore, U.S. EPA has not developed a cancer slope factor for lead. According to U.S. EPA (1998) guidance, the hazard posed by lead should be evaluated by comparing estimated concentrations in soil with a concentration of 400 milligrams per kilogram (mg/kg). U.S. EPA's IEUBK model predicts that the concentration of lead in blood will exceed 10 micrograms per deciliter in no more than 5 percent of children exposed to a concentration of lead in soil of 400 mg/kg. Projected concentrations of lead in soil for each agent campaign were compared with the 400 mg/kg concentration to assess the potential for lead toxicity.

In addition, the maximum concentration of lead in air was estimated and compared to the National Ambient Air Quality Standard (quarterly average) of 1.5 micrograms per cubic meter ($\mu g/m^3$) (value listed on-line at http://www.epa.gov/airs/criteria.html).

3.7 EVALUATION OF CHROMIUM

As discussed in the protocol, available analytical data on chromium in emissions were limited to measurements of total concentrations of chromium; no data on speciated forms of chromium were available for the risk assessment. In the absence of this information, U.S. EPA (1998) recommends assuming that all exposure is to hexavalent chromium, the most toxic form of the element. However, U.S. EPA guidance also recognizes that this assumption probably overestimates the potential for adverse health effects from chromium because hexavalent chromium is readily converted in the environment to the less toxic, trivalent form. Therefore, the risk assessment assumed emissions were composed entirely of hexavalent chromium to evaluate the potential for adverse health effects from chromium. The risk assessment also evaluated chromium as if emissions were composed entirely of trivalent chromium.

In accordance with U.S. EPA (1998) guidance, hexavalent chromium was evaluated as an oral and an inhalation hazard, and as an inhalation carcinogen. Hexavalent chromium was not evaluated as an oral carcinogen because none of the available information suggests that ingested hexavalent chromium causes cancer (IRIS, 2003). Trivalent chromium was evaluated as an oral and an inhalation hazard only because it is not carcinogenic.

3.8 EVALUATION OF MERCURY

Mercury was evaluated according to U.S. EPA (1998) guidance, which recommends assuming that mercury (measured as total mercury in stack emission samples) emissions are in inorganic forms. Mercury deposited to environmental media was also assumed to be in inorganic forms. After it is deposited, U.S. EPA (1998) methods assume a fraction of the deposited mercury is converted to methyl mercury, an organic and more toxic form; the balance of the mercury is assumed to be divalent mercury. Therefore, the risk assessment evaluated both inorganic mercury, modeled as mercuric chloride, and organic mercury, modeled as methyl mercury.

4.0 RISK CHARACTERIZATION

The risk characterization was carried out to meet the following objectives: (1) estimate and describe a range of cancer risk and non-carcinogenic hazard for each agent campaign and agent campaigns combined; (2) evaluate the uncertainties associated with the risk and hazard estimates, including the evaluation of the significance of estimated risk and hazard values that exceed target levels. The calculated risks and hazards and a discussion regarding PCBs, dioxins, and lead are presented in Section 4.1. Section 4.2 discusses the COPCs with calculated risks or hazards above the target levels. The major uncertainties associated with the risk characterization are presented in Section 4.3.

4.1 ESTIMATION AND DESCRIPTION OF POTENTIAL RISKS AND HAZARDS

Potential risks and hazards were evaluated for people that (1) reside and ranch in the assessment area, (2) work at DCD, and (3) engage in recreational activities in the assessment area. Section 4.1.1 presents the TOCDF source-specific risks and hazards for each agent campaign based on the assessment of all COPCs, which includes those compounds detected in emissions and the non-detected compounds evaluated at the analytical detection limit in the stack gas. Section 4.1.2 presents the TOCDF source-specific risks and hazards for each agent campaign based on detected COPCs only. Section 4.1.3 presents the source-specific risks and hazards associated with CAMDS sources; these results are based on worst-case COPC-specific emission rates among the three agent campaigns. Section 4.1.4 presents the estimates of cumulative risks and hazards for sources at both TOCDF and CAMDS. Section 4.1.5 presents the results of the evaluation of risks to the subsistence rancher based on the ingestion of ranch-raised mutton and goat's milk. Section 4.1.6 discusses the risk and hazard for a subsistence rancher that works and DCD. Section 4.1.7 presents the results of the evaluation of acute inhalation hazards. Sections 4.1.8 through 4.1.10 discuss the results of the assessment of risks and hazards associated with PCBs, dioxins, and lead.

IRAP-*h* View output was exported into a Microsoft Access® database to manage and query the information to meet report and DSHW risk management objectives. All reported risks and hazards for individual emission sources are based on the receptor locations with the greatest cumulative risks and greatest cumulative hazards. For sources with risks and hazards exceeding reporting levels, additional queries were used to identify individual COPCs with cancer risk values and hazard values that exceed the HHRA target levels.

For the evaluation of the TOCDF sources, a range of risk and hazard is calculated. The upper value is set as the risk or hazard equal to the total risk or hazard presented by "all COPCs," which include compounds detected in one or more stack gas samples ("detects") and compounds not detected in stack gas samples ("non-detects"). At the lower end of the range, risk or hazard is equal to the total risk or hazard presented by detected COPCs only. This risk is described as "detected COPCs only." The differences between the upper and lower values are equal to the risks or hazards presented by non-detected COPCs. The risk assessment for these COPCs was based on their analytical detection limit. The analytical detection limits used in the HHRA are the detection limits reported in the original test burn reports. Typically, these values were the practical quantitation limits. A common use of the "less-than" symbol is that an analyte was not detected. However, in JACADS reports, the less than symbol means that the analyte was not detected in at least one portion of the sampling train. If an analyte was detected in all components of a sampling train but one, JACADS reports the value with a "less than" symbol. When JACADS data was used as a surrogate source of emissions data for this HHRA, the risks and hazards for detected COPCs only should be interpreted with the caveat that JACADS use of "less-than" deviates from the common usage.

The risk and hazard estimates are compared to the target levels. The target level for carcinogenic effects of 1×10^{-5} (1E-05), or 1 in 100,000, is the same target level used for the TOCDF screening risk assessment (ATK 1996). The 1E-05 value is consistent with existing DSHW rules and policies. A 1E-05 excess lifetime cancer risk means that if one hundred thousand people were exposed, there could be up to one additional case of cancer over a lifetime. The target level for non-carcinogenic effects is a hazard quotient (HQ) or hazard index (HI) of 0.25, depending on whether a single compound or a group of compounds is being evaluated; it is the same target level used for the TOCDF screening risk assessment (ATK 1996). Although no adverse health effects are predicted if the HQ or HI is less than 1, the level of 0.25 (which is four times more protective) is selected to account for potential existing exposures that do not originate at DCD. When the HQ or HI is equal to 1, the calculated dose is equal to a virtually safe dose and no adverse health effects are likely. If the calculated values for carcinogenic and non-carcinogenic endpoints are less than the target levels, potential exposures to emissions are considered safe and acceptable. A calculated endpoint that exceeds the target level does not indicate an unsafe action or an unacceptable risk, but indicates that additional evaluation or mitigation is warranted.

All risk and hazard values greater than reporting levels are reported. Only the risk and hazard values that exceed reporting levels are reported in the main body of this report. The complete results are provided in the appendices. The reporting levels are 10 times lower (more stringent) than the target levels. The reporting level for cancer risk is 1E-06 (one excess case of cancer in one million individuals), and the reporting level for adverse non-carcinogenic effects is an HI of 0.025. Therefore, all risks and hazards that exceed the target levels also exceed the reporting levels. The purpose for reporting risks and hazards that exceed reporting levels, but not target levels, is to identify COPCs that are close to (within a factor of 10), but do not exceed target levels. Only exposure scenarios and COPCs with calculated risks or hazards above the target levels require additional evaluation or mitigation. If an exposure scenario or COPC is not discussed in the main body of the report, then the calculated risks and hazards are below the reporting and target levels.

4.1.1 TOCDF Risks and Hazards from All COPCs

Agent-specific IRAP-*h* View iterations with all COPCs (detected and non-detected COPCs) were completed for all exposure scenarios to:

- Calculate agent-specific risk and hazard values
- Identify specific COPCs that present risk or hazard that exceed reporting levels or target levels.

The "all COPCs" analysis indicates that the agent-specific risks and hazards for several exposure scenarios exceed target levels. **In general, non-detected COPCs present most of the risks and hazards for these exposure scenarios**. The following COPCs present risk or hazard that exceed target levels for one or more of the exposure scenarios evaluated in the risk assessment:

- Ethyl methanesulfonate (EMS)
- Total mercury (modeled as methyl mercury)
- Di-n-octylphthalate (DNOP)
- Polycyclic aromatic hydrocarbons (PAHs)
  - Dibenz(a,h)anthracene
  - Indeno(1,2,3-cd)pyrene

EMS, DNOP, and the two PAHs were not detected in stack emissions. The remaining two COPCs, DNOP and total mercury (modeled as methyl mercury), were detected in stack emissions.

The sections below present the source-specific “all COPCs” cumulative cancer risks and HI values that exceed the reporting levels of 1E-06 and 0.025; these values are tabulated for each exposure scenario. Risks and hazards are specific to each agent campaign. Risk values are reported to one significant digit; HI values are reported to two significant digits. In these tables, the source-specific risks and hazards are tabulated for all COPCs. The source-specific risks and hazards are summed to represent the total risk and total hazard for each exposure scenario. The total risks and hazards are based on source-specific risks and hazards, including sources with values less than the reporting levels. Therefore, the totaled values may not equal the sums of the values for sources listed in the table. The source-specific receptor location that corresponds to maximum cancer risk and hazard for each exposure scenario is also listed. These receptor locations are shown on Figure 4-1.

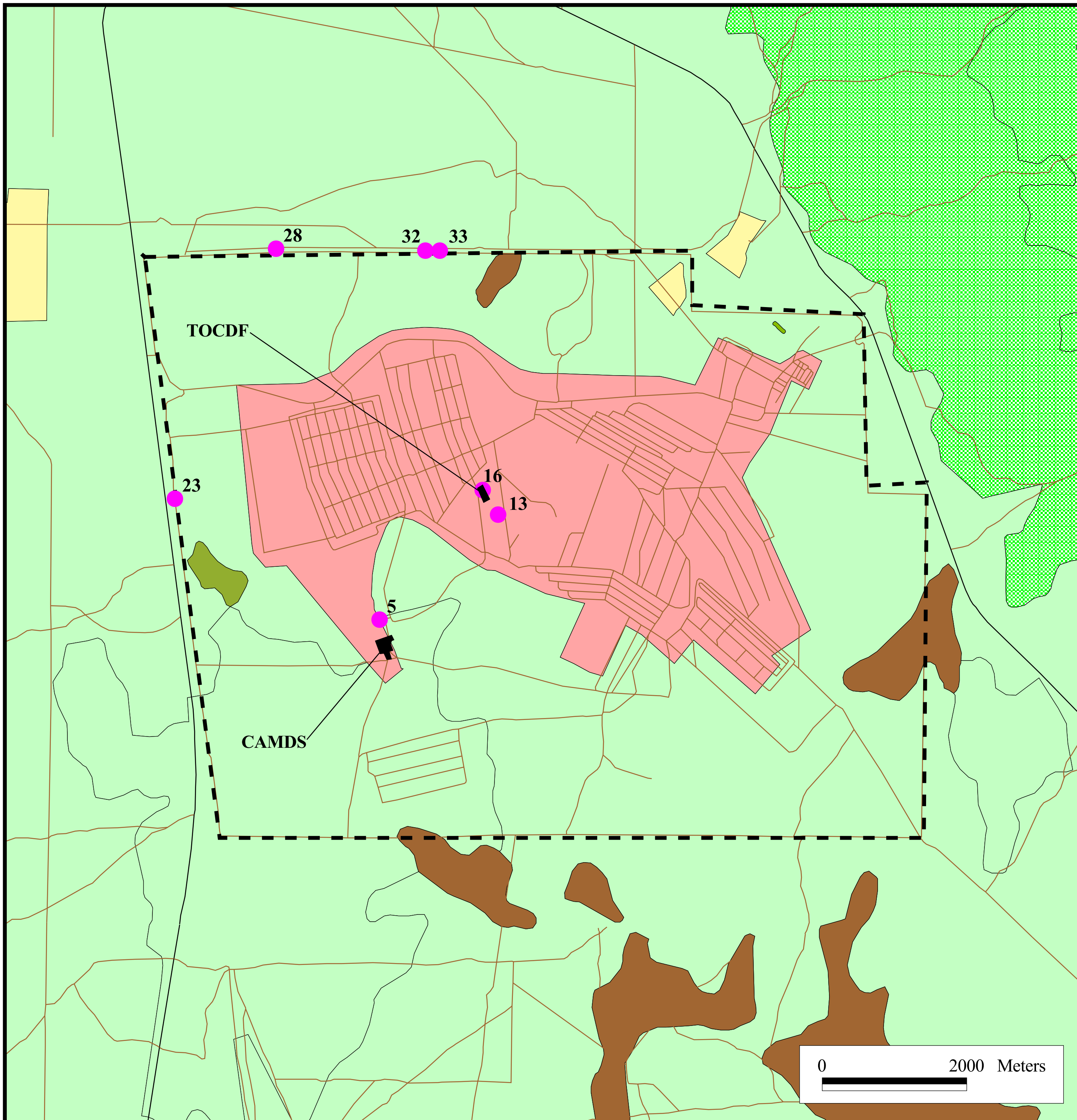
4.1.1.1 GB Campaign

The cancer risks associated with treatment of GB at one or more TOCDF sources exceed the reporting level of 1E-06, and the target level of 1E-05 for the adult and child subsistence rancher scenarios (Table 4-1). The HI values associated with treatment of GB at one or more TOCDF sources exceed the reporting level of 0.025, and the target level of 0.25 for the adult and child recreationist scenarios, and the adult and child fisher scenarios (Table 4-2).

For the adult and child subsistence rancher scenarios, emissions from the TOCDF MPF are the source of the highest cancer risk (2E-04 for the adult rancher) and the highest HI (1,000 for the child rancher) values. Excess risk to the subsistence rancher adult for the MPF is attributed to PAHs (listed above) and EMS. The risk from benzo(a)pyrene from all sources combined was greater than reporting levels. DNOP poses more than 99 percent of the hazard to the subsistence rancher child for the MPF. The hazard from 2,4,-dinitrophenol for all sources combined was above the reporting level. The IRAP-*h* View output file for the adult and child subsistence rancher scenario is presented in Appendix F-1.

The resident had a calculated risk greater than the reporting level from EMS. The on-site worker had a calculated risk greater than the reporting level from EMS at Receptor location 16 shown on Figure 4-1. The risk and hazards for the resident, on-site worker, SunTen water skier are less than target levels. The complete results are available in Appendices F-2 through F-4.

The adult and child recreationist scenario was evaluated to assess potential future exposures associated with ingestion of fish caught from Rush Lake and incidental ingestion of water from the lake. No sources at TOCDF present cancer risk that exceeds the target level but the risks from dibenz(a,h)anthracene were higher than reporting levels when all sources were combined. In terms of hazard, the HI values for the LIC 1 and LIC 2 exceed the target HI level for both the adult and child recreationist (Table 4-2). Approximately 97 percent of the HI values for the adult and child recreationists are due to emissions from the LICs but as will be discussed in Section 4.1.5, the portion of the hazards attributed to the LICs may be overestimated and portion attributed to the MPF may be underestimated. These hazards are associated with total mercury, modeled as methyl mercury, through the fish ingestion pathway. Hazard was modeled using the concentration of the COPC in water and sediment for the receptor location nearest to Rush Lake. The recreationist scenario was evaluated for a hypothetical person that may fish at Rush Lake, regardless of where the person resides. As such, no number is assigned to the receptor location that corresponds to the maximum off-site impact. The IRAP-*h* View output file for the recreationist scenario is presented in Appendix F-5.



LEGEND

LANDUSE CLASSIFICATION

- AGRICULTURAL
- BARREN LAND
- FOREST LAND
- URBAN OR BUILT-UP LAND
- SHRUB/GRASS LAND
- WETLAND

DESERET CHEMICAL DEPOT BOUNDARY

5 RECEPTOR LOCATION

N
W
E
S

NOTES:
CAMDS = CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM
TOCDF = TOOELE CHEMICAL AGENT DISPOSAL FACILITY

SOURCES: U.S. ENVIRONMENTAL PROTECTION AGENCY, 1977, AND THE STATE OF UTAH DIVISION OF INFORMATION TECHNOLOGY SERVICES AUTOMATED GEOGRAPHIC REFERENCE CENTER, JULY 2000.

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF SOLID AND HAZARDOUS WASTE

FIGURE 4-1
RECEPTOR LOCATIONS WITH MAXIMUM RISK OR HAZARD

TETRA TECH EM INC.

TABLE 4-1 CANCER RISKS FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF GB — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	32	DFS	7E-05	2E-05
		LIC 1	4E-05	1E-05
		MPF	2E-04	5E-05
		LIC 2	8E-05	2E-05
		BRA	6E-06	2E-06
		Total Cancer Risk	**4E-04**	**1E-04**
Resident	32	DFS	1E-06	<1E-06
		MPF	3E-06	2E-06
		LIC 2	1E-06	1E-06
		Total Cancer Risk	**7E-06**	**5E-06**
On-Site Worker	16	MPF	2E-06	NE
		Total Cancer Risk	**3E-06**	**NE**
Rush Lake Recreationist	NA	No source with risk > 1E-06	– –	– –
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:
See Section 4.1 for description of target levels and reporting levels

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
GB	Isopropyl methylphosphonofluoridate
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

Ingestion of fish that might be caught at Rainbow Reservoir was evaluated to assess potential exposures to people who may fish at this water body. The results of this evaluation were similar to the Rush Lake fish ingestion pathway evaluated for the fisher adult and child exposure scenarios. The HI values for the LIC 1 and LIC 2 exceed the target level for the adult and child fisher exposure scenarios. Similar to Rush Lake discussed above, a receptor location that corresponds to the maximum impact was not identified. The IRAP-*h* View output file for the adult and child fisher scenario for Rainbow Reservoir is presented in Appendix F-6.

TABLE 4-2 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF GB — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	32	BRA	<0.025	0.003
		DFS	230	410
		LIC 1	130	240
		MPF	570	1,000
		LIC 2	280	500
Total Non-Carcinogenic Hazard			**1,200**	**2,200**
Resident	32	MPF	<0.025	0.015
Total Non-Carcinogenic Hazard			**<0.025**	**0.038**
Rush Lake Recreationist	NA	BRA	0.16	0.011
		DFS	0.05	0.033
		LIC 1	4.3	2.8
		MPF	0.049	0.032
		LIC 2	4.3	2.8
Total Non-Carcinogenic Hazard			**8.9**	**5.8**
Rainbow Reservoir Fisher	NA	BRA	0.092	0.06
		DFS	0.025	<0.025
		LIC 1	1.9	1.2
		LIC 2	1.9	1.2
Total Non-Carcinogenic Hazard			**3.9**	**2.5**

Notes:

See Section 4.1 for description of target levels and reporting levels

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
GB	Isopropyl methylphosphonofluoridate
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

4.1.1.2 VX Campaign

The cancer risk associated with the predicted emission from the treatment of VX munitions at one or more TOCDF sources exceeds the reporting level of 1E-06, and the target level of 1E-05 for the adult and child subsistence rancher scenarios and the adult and child resident scenarios. The maximum source-specific risks, and the corresponding receptor locations, for these scenarios are listed in Table 4-3. The HI values for one or more TOCDF sources exceed the reporting level of 0.025, and the target level of 0. 25 for the adult and child subsistence rancher scenarios and the adult recreationist scenario. The maximum source-specific HI values and the corresponding receptor locations for these scenarios are listed in Table 4-4.

TABLE 4-3 CANCER RISKS FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF VX — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	32	DFS	7E-05	2E-05
		LIC 1	4E-05	1E-05
		MPF	1E-05	6E-06
		LIC 2	4E-05	1E-05
		Total Cancer Risk	**2E-04**	**5E-05**
Resident	32	DFS	1E-06	<1E-06
		MPF	2E-06	1E-06
		Total Cancer Risk	**5E-06**	**3E-06**

Notes:

See Section 4.1 for description of target levels and reporting levels

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonthiolate

Emissions from the TOCDF DFS are the source of the highest cancer risk (7E-05 for the adult) and the highest HI (1,400 for the child) for the adult and child subsistence rancher scenarios. Several sources present risk and hazard that exceed target levels of 1E-05 and an HI of 0.25 for the adult subsistence rancher. Similar to the evaluation of emissions from the GB campaign, excess cancer risks are attributable to PAHs and EMS. Similarly, DNOP presents more than 99 percent of the hazards. The maximum cancer risk values correspond to receptor location 32, and the maximum HI values correspond to receptor location 33 (Figure 4-1). The IRAP-*h* View output file for the adult and child subsistence rancher scenarios for the VX campaign is presented in Appendix G-1.

For the onsite worker, adult and child resident, adult and child Rainbow Reservoir fisher, child recreationist, and Sunten water skier scenarios the total cancer risk and HI values are less than the target levels. The calculated risk from EMS exceeded the reporting level for the adult resident. The IRAP-*h* View output files for the VX campaign are presented in Appendix G.

None of the cancer risk values calculated for the adult and child recreationist scenarios exceed the target level. The calculated HI value for the adult recreationist scenario calculated for the TOCDF BRA and DFS units exceeds the target level. The HI values for these sources and the total HI values above target levels are listed in Table 4-4. More than 99 percent of the calculated hazards are attributed to total mercury (modeled as methyl mercury) associated with ingestion of fish caught from Rush Lake, which was evaluated as a potential future pathway. The IRAP-*h* View output file for the recreationist adult and child scenarios for the VX campaign is presented in Appendix G-5.

TABLE 4-4 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF VX — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33	BRA	0.06	<0.025
		LIC1	13	24
		MPF	12	22
		LIC2	13	24
		DFS	770	1,400
		Total Non-Carcinogenic Hazard	**800**	**1,500**
Rush Lake Recreationist	NA	BRA	0.11	0.074
		DFS	0.13	0.083
		Total Non-Carcinogenic Hazard	**0.26**	**0.17**
Rainbow Reservoir Fisher	NA	BRA	0.038	0.025
		DFS	0.037	<0.025
		Total Non-Carcinogenic Hazard	**0.08**	**0.052**

Notes:

See Section 4.1 for description of target levels and reporting levels

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
TOCDF	Tooele Chemical Agent Disposal Facility
VX	O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

4.1.1.3 Sulfur Mustard Campaign

The cancer risk associated with the predicted emissions from the treatment of sulfur mustard munitions at one or more TOCDF sources exceeds the reporting level of 1E-06, and the target level of 1E-05 for the subsistence rancher adult and child scenarios. The maximum source-specific risks and the corresponding receptor locations for these scenarios are listed in Table 4-5. HI values associated with treatment of VX munitions at one or more TOCDF sources exceed the reporting level of 0.025, and the target level of 0. 25 for the subsistence rancher adult and child scenarios, the adult and child recreationist scenarios, and the fisher adult and child scenarios. The maximum source-specific HI values and the corresponding receptor locations for these scenarios are listed in Table 4-6.

For the subsistence rancher adult and child scenarios, predicted emissions from the DFS, LIC 1, MPF, and LIC 2 units at TOCDF present cancer risks and HI values that exceed the target levels (Tables 4-5 and 4-6). Maximum risks were associated with the DFS — 2E-04 for the subsistence rancher adult and 5E-05 for the subsistence rancher child. The DFS also presented the maximum HI values — 650 for the subsistence rancher adult and 1,200 for the subsistence rancher child. Similar to the results of the evaluation of these scenarios for the GB and VX campaigns, the elevated cancer risks are a result of risk from PAHs. The combined risks from all sources exceeded the reporting level for benzo(a)pyrene, EMS, and 1,2,3,7,8-pentachlorodibenzo(p)dioxin. The elevated hazards are attributed mainly to DNOP, which accounted for more than 99 percent of the hazard. In addition, hazards posed by 2,4-dinitrophenol and mustard for the subsistence rancher adult and child scenarios exceed the reporting level. The maximum cancer risk values correspond to receptor location 32, and the maximum HI values correspond to receptor

TABLE 4-5 CANCER RISKS FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	32	DFS	2E-04	5E-05
		LIC 1	4E-05	1E-05
		MPF	6E-05	2E-05
		LIC 2	4E-05	1E-05
		Total Cancer Risk	**3E-04**	**1E-04**
Resident	32	DFS	3E-06	2E-06
		Total Cancer Risk	**5E-06**	**3E-06**
On-Site Worker	16	No source with risk > 1E-06	– –	NE
		Total Cancer Risk	**1E-06**	**NE**
Rush Lake Recreationist	NA	DFS	1E-06	<1E-06
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:

See Section 4.1 for description of target levels and reporting levels

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

location 33. The IRAP-*h* View output file for the subsistence rancher adult and child scenarios for the sulfur mustard campaign is presented in Appendix H-1.

The cancer risks and hazard indices for the adult and child resident, SunTen water skier, and on-site worker scenarios were above reporting levels but below target levels (Tables 4-5 and 4-6). The risk from the adult resident's calculated exposure to EMS was above the reporting level. The hazard for the child resident was above the reporting level for calculated exposures to 2,4-dinitrophenol and mustard. The mustard hazard for the on-site worker exceeded the reporting level. The IRAP-*h* View output files for the sulfur mustard campaign are presented in Appendix H.

For the adult recreationist scenario, the calculated cancer risk is above the reporting level but below the target level. For the child recreationist scenario, the calculated cancer risk is below the reporting level. In terms of hazard, the combined HI values for all TOCDF sources for both the adult and child scenarios exceeds the target level of 0.25. The MPF is the only individual source with HI values greater than the target level. Similar to the results for the GB and VX campaigns, the HQ values above the target level are attributable to methyl mercury for the fish ingestion pathway. The IRAP-*h* View output file for the adult and child recreationist scenarios for the sulfur mustard campaign is presented in Appendix H-5.

For the evaluation of the Rainbow Reservoir fisher adult and child scenarios, no source presents risk above the target level. The HI values for the fisher adult and child scenarios for the MPF exceed the

TABLE 4-6 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED THE REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — ALL COPCs				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33			
		DFS	650	1,200
		LIC 1	20	36
		MPF	200	360
		LIC 2	20	36
		Total Non-Carcinogenic Hazard	**890**	**1,600**
Resident		MPF	<0.025	0.046
		DFS	<0.025	0.033
		Total Non-Carcinogenic Hazard	**0.034**	**0.11**
On-Site Worker	16	MPF	0.063	NE
		Total Non-Carcinogenic Hazard	**0.11**	**NE**
Rush Lake Recreationist	NA	BRA	0.12	0.077
		DFS	0.043	0.028
		LIC 1	0.10	0.066
		MPF	1.7	1.1
		LIC 2	0.10	0.066
		Total Non-Carcinogenic Hazard	**2.1**	**1.3**
Rainbow Reservoir Fisher	NA	BRA	0.042	0.027
		LIC 1	0.028	<0.025
		MPF	0.48	0.31
		LIC 2	0.028	<0.025
		Total Non-Carcinogenic Hazard	**0.59**	**0.39**

Notes:

See Section 4.1 for description of target levels and reporting levels

BRA	Brine reduction area
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.
TOCDF	Tooele Chemical Agent Disposal Facility

target level. The IRAP-*h* View output file for the adult and child fisher scenario for Rainbow Reservoir for the sulfur mustard campaign is presented in Appendix H-6.

4.1.2 TOCDF Risks and Hazards from Detected COPCs Only

As described in Section 4.1.1, most of the COPCs that present a calculated risk or hazard above the target levels were evaluated as non-detected compounds with emission rates calculated from the analytical detection limit in the stack gas. To determine the risks and hazards for only the compounds that were detected in stack emissions, similar analyses were performed for detected COPCs only. The risks and hazards posed by detected COPCs in emissions from the treatment of each agent are summarized in Tables 4-7 through 4-9. The receptor locations that correspond to the maximum risk and hazard values are also listed.

The IRAP-*h* View output files used for the analyses on the detected COPCs are the same as those used in the "all COPCs" analyses described in Sections 4.1.1.1 through 4.1.1.3. The Microsoft Access database in Appendix A was queried for risk and hazard values of detected COPCs only. As noted in Section 4.1, when emissions data from JACADS was extrapolated to TOCDF, some COPCs may be inaccurately classified as not-detected. Reports on risk and hazards for each exposure scenario for each agent campaign were generated in *.pdf format.

4.1.2.1 GB Campaign

For the GB campaign, source-specific cancer risk values for all exposure scenarios are less than the reporting level indicating that cancer risk above target levels for the GB campaign is based on non-detected COPCs (PAHs and EMS) assumed to be present at the analytical detection limit in stack emissions. In regard to non-carcinogenic hazard, total HI values based on detected COPCs only for the adult and child recreationist scenarios and the fisher adult and child scenarios exceed the reporting level, and the target level of 0.25 (Table 4-7). These values are similar to the HQs calculated for "all COPCs" (Table 4-2) indicating that the majority of the calculated hazard is attributable to mercury detected in stack emissions. The subsistence rancher HI for the detected COPCs is less than reporting levels indicating that the HI above the target level (Table 4-2) for the GB campaign is based on non-detected DNOP assumed to be present in stack emissions at the analytical detection limit. The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices I-1 through I-6.

4.1.2.2 VX Campaign

For the VX campaign, source-specific cancer risk values for all exposure scenarios are less than the reporting level indicating that cancer risk above the target level for the GB campaign is based on non-detected COPCs (PAHs) assumed to be present at the analytical detection limit in stack emissions. The total HI values for the rancher adult and child scenarios exceed the target level for hazard (Table 4-8). These HIs indicate that the majority of the calculated hazard is from COPCs that were detected in stack emissions, primarily DNOP. DNOP has not been detected in stack emissions from the TOCDF (or JACADS) but was detected during one run of the CAMDS VX M55 rocket trial burn. The CAMDS trial burn data was used as a surrogate for predicting emissions from the TOCDF DFS until TOCDF conducts a VX trial burn. The difference in HI values reported for all COPCs in Table 4-4 and detected COPCs only in Table 4-8 is attributable to DNOP evaluated at the analytical detection limit for the other sources. The HIs for all of the other exposure scenarios were below target levels, which indicates the HI above the target level for the adult Rush Lake Recreationist is attributable to nondetected mercury.

The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices J-1 through J-6.

TABLE 4-7 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF GB — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Rush Lake Recreationist	NA	DFS	0.051	0.033
		LIC 1	4.3	2.8
		MPF	0.049	0.031
		LIC 2	4.3	2.8
		Total Non-Carcinogenic Hazard	**8.7**	**5.7**
Rainbow Reservoir Fisher	NA	DFS	0.025	<0.025
		LIC 1	1.9	1.2
		LIC 2	1.9	1.2
		Total Non-Carcinogenic Hazard	**3.8**	**2.4**

Notes:

See Section 4.1 for description of target levels and reporting levels
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable for water bodies. See text for discussion.
TOCDF Tooele Chemical Agent Disposal Facility

TABLE 4-8 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF VX — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	33	DFS	770	1,400
		Total Non-Carcinogenic Hazard	**770**	**1,400**
Rush Lake Recreationist	NA	DFS	0.13	0.082
		Total Non-Carcinogenic Hazard	**0.13**	**0.086**
Rainbow Reservoir Fisher	NA	DFS	0.037	0.025
		Total Non-Carcinogenic Hazard	**0.039**	**0.025**

Notes:

See Section 4.1 for description of target levels and reporting levels
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
NA Not applicable for water bodies. See text for discussion.
TOCDF Tooele Chemical Agent Disposal Facility

TABLE 4-9 HAZARD INDICES FOR TOCDF SOURCES THAT EXCEED DSHW REPORTING LEVEL FOR TREATMENT OF SULFUR MUSTARD — DETECTED COPCs ONLY				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Rush Lake Recreationist	NA	DFS	0.043	0.028
		LIC 1	0.10	0.066
		LIC 2	0.10	0.066
		Total Non-Carcinogenic Hazard	**0.25**	**0.16**
Rainbow Reservoir Fisher	NA	LIC 1	0.028	<0.025
		LIC 2	0.028	<0.025
		Total Non-Carcinogenic Hazard	**0.07**	**0.045**

Notes:

See Section 4.1 for description of target levels and reporting levels

COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
LIC	Liquid incinerator
NA	Not applicable for water bodies. See text for discussion.
TOCDF	Tooele Chemical Agent Disposal Facility

4.1.2.3 Sulfur Mustard Campaign

For the VX campaign, source-specific cancer risk values for all exposure scenarios are less than the reporting level indicating that cancer risk above the target level for the GB campaign is based on non-detected COPCs (PAHs and EMS) assumed to be present at the analytical detection limit in stack emissions. As shown in Table 4-9, calculated hazards exceeded the reporting level but not the target level of 0.25. The total HI value for the adult Rush Lake recreationist is 0.25. The HIs for all other exposure scenarios are less than the target level. For the subsistence rancher scenario, the difference in calculated HIs for all COPCs in Table 4-6 and for detected COPCs in Table 4-9 indicate that the HIs above target levels are attributable to non-detected COPCs. DNOP was assumed to be present in stack emissions at the analytical detection limit, which results in HIs greater than the target level for the subsistence rancher scenario. For the Rush Lake recreationist and Rainbow Reservoir fisher there is a decrease in the calculated HIs between “all COPCs” and “detected COPCs only” because mercury was reported as “less-than” in the JACADS MPF trial burn report used to estimate emissions. As noted in Section 3.4.1, a “less-than”, as reported by JACADS, is not the same as not-detected. Mercury was detected during the JACADS mustard trial burn for the MPF and therefore, the HIs for the Rush Lake recreationist and Rainbow Reservoir fisher for all COPCs and detected COPCs should the same.

The Microsoft Access reports for each exposure scenario discussed above are presented in Appendices K-1 through K-6.

4.1.3 CAMDS Risks and Hazards

The risk assessment for the CAMDS sources was performed using one set of worst-case, source-specific emission rates, as discussed in Section 3.3.4. The source-specific emission rate for each COPC was identified as the highest emission rate among those estimated for each agent campaign. These emission rates do not distinguish between detected and non-detected COPCs. Risks and hazards for each exposure scenario were calculated by summing source-specific risks and hazards based on the receptor location with the highest total cancer risk value and the receptor location with the highest total HI value. Presented below are the source-specific risks and hazards for the subsistence rancher adult and child scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the fisher adult and child scenarios. Risk values and HI values exceeding reporting levels are presented in Tables 4-10 and 4-11, respectively.

4.1.3.1 Subsistence Rancher Adult and Child Scenarios

The highest risks and hazards for the subsistence rancher adult and child scenarios correspond to receptor location 23, which is northwest of CAMDS along the western boundary of DCD. Total risks of 5E-04 for the subsistence rancher adult scenario and 1E-04 for the subsistence rancher child scenario were calculated. The DFS presents risks of 3E-04 and 9E-05 for the adult and child scenarios, respectively. The MPF presents risks of 2E-04 and 5E-05 for the adult and child scenarios, respectively. Individual COPCs with risk values that exceed the reporting level include dioxins, EMS and three PAHs: dibenz(a,h)anthracene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene. In addition, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene also present risks that exceed the target level.

In terms of hazard, total HI values of 1,700 for the adult scenario and 3,100 for the child scenario were calculated. The DFS presents HI values of 1,100 and 2,000 for the subsistence rancher adult and subsistence rancher child scenarios, respectively. The MPF presents HI values of 630 and 1,100 for the subsistence rancher adult and subsistence rancher child scenarios, respectively. HQ values for both 2,4-dinitrophenol and DNOP exceed the reporting level. However, more than 99 percent of the hazard is due to DNOP. The IRAP-*h* View output file for the analysis of risks and hazards for the subsistence rancher adult and child scenarios is presented in Appendix L-1.

4.1.3.2 Adult and Child Resident Scenarios

Highest risks and hazards for the adult and child resident scenarios also correspond to receptor location 23. Total cancer risks of 6E-06 for the adult scenario and 5E-06 for the child scenario were calculated. The DFS presents risks of 4E-06 and 3E-06 for the adult and child scenarios, respectively. The MPF presents risk 2E-06 for both scenarios. The DFS and MPF EMS risk values for both scenarios are below the target level.

In terms of hazard, total HI values of 0.029 for the resident adult scenario and 0.070 for the resident child scenario were calculated. The resident child HI values for the DFS and MPF exceed the reporting level but are less than the target level. Unit-specific HI values for the resident adult scenario are less than the reporting level. All COPC HQ values were less than the reporting level for hazard. The IRAP-*h* View output file for the analysis of risks and hazards for the adult and child resident scenarios is presented in Appendix L-2.

4.1.3.3 On-Site Worker Scenario

The highest cancer risks for the on-site worker scenario correspond to receptor location 5, which is on the north side of the CAMDS facility. The DFS and MPF units at CAMDS present risks above the reporting level of 1E-06, but below the target level of 1E-05. Total risk was calculated at 6E-06. Two COPCs, EMS and chromium (modeled as hexavalent), are mainly responsible for risk. In terms of hazard, a total HI value equal to 0.054 was calculated. The DFS and MPF present HI values of 0.029 and 0.025, respectively. No single COPC presents an HQ value that exceeds the DSHW reporting level of 0.025. The IRAP-*h* View output file for the analysis of CAMDS risks and hazards for the on-site worker scenario is presented in Appendix L-3.

TABLE 4-10 CANCER RISKS FOR CAMDS SOURCES THAT EXCEED THE REPORTING LEVEL				
Exposure Scenario	**Receptor Location**	**Source**	**Cancer Risk**	
			Adult	**Child**
Subsistence Rancher	23	DFS	3E-04	9E-05
		MPF	2E-04	5E-05
		Total Cancer Risk	**5E-04**	**1E-04**
Resident	23	DFS	4E-06	3E-06
		MPF	2E-06	2E-06
		Total Cancer Risk	**6E-06**	**5E-06**
On-Site Worker	5	DFS	3E-06	NE
		MPF	3E-06	NE
		Total Cancer Risk	**6E-06**	**NE**
Rush Lake Recreationist	NA	DFS	1E-06	<1E-06
		Total Cancer Risk	**2E-06**	**<1E-06**

Notes:

See Section 4.1 for description of target levels and reporting levels

CAMDS	Chemical Agent Munitions Disposal System
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
MPF	Metal parts furnace
NA	Not applicable for evaluation of water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.

4.1.3.4 SunTen Water Skier Scenario

The total risks and hazards for the incidental ingestion of water scenario for the SunTen water ski lakes are well below the reporting levels of 1E-06 for risk and 0.025 for hazard. The IRAP-*h* View output file for the analysis of risks and hazards for this scenario is presented in Appendix L-4.

4.1.3.5 Rush Lake Adult and Child Recreationist Scenarios

For the adult recreationist scenarios, a total cancer risk of 2E-06 was calculated. The risk for the child recreationist scenario is less than the reporting level. The calculated risk of 1E-06 for the DFS (for the adult recreationist) exceeds the reporting level; however, no single COPC presents risk exceeding the reporting level. Risk for the MPF is less than the reporting level. In terms of hazard, total HI values of 3.5 for the adult recreationist scenario and 2.3 for the child recreationist scenario were calculated. The DFS and MPF present HI values for the adult scenario that exceed the reporting level of 0.025 as well as the target level of 0.25. The DFS HI value for the child scenario exceeds the reporting level and equals the target level. The MPF HI value for the child scenario exceeds the target level. Excess HI values are due to methyl mercury exposure through the fish ingestion pathway. The IRAP-*h* View output file for the analysis of risks and hazards for the adult and child recreationist scenarios is presented in Appendix L-5.

TABLE 4-11 HAZARD INDICES FOR CAMDS SOURCES EXCEEDING THE REPORTING LEVEL				
Exposure Scenario	**Receptor Location**	**Source**	**Hazard Index**	
			Adult	**Child**
Subsistence Rancher	23	DFS	1,100	2,000
		MPF	630	1,100
		Total Non-Carcinogenic Hazard	**1,700**	**3,100**
Resident	23	DFS	<0.025	0.038
		MPF	<0.025	0.032
		Total Non-Carcinogenic Hazard	**0.029**	**0.070**
On-Site Worker	5	DFS	0.029	NE
		MPF	0.025	NE
		Total Non-Carcinogenic Hazard	**0.054**	**NE**
Rush Lake Recreationist	NA	DFS	0.38	0.25
		MPF	3.1	2.0
		Total Non-Carcinogenic Hazard	**3.5**	**2.3**
Rainbow Reservoir Fisher	NA	DFS	0.092	0.059
		MPF	0.74	0.48
		Total Non-Carcinogenic Hazard	**0.83**	**0.54**

Notes:

See Section 4.1 for description of target levels and reporting levels

CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
MPF	Metal parts furnace
NA	Not applicable for water bodies. See text for discussion.
NE	Not evaluated for on-site worker scenario.

4.1.3.6 Rainbow Reservoir Fisher Adult and Child Scenarios

For the evaluation of the Rainbow Reservoir fish ingestion pathway, no sources at CAMDS present risk greater than the reporting level. In terms of hazard, total HI values of 0.83 and 0.54 were calculated for the adult and child scenarios, respectively. The HI values for the DFS and MPF exceed the reporting level of 0.025 for both the adult and child fisher scenarios. In addition, the adult and child HI values for the MPF exceed the target level of 0.25. The elevated HI values are due to potential methyl mercury exposures. The IRAP-*h* View output file for the analysis of risks and hazards for the fisher adult and child scenarios is presented in Appendix L-6.

4.1.4 Cumulative Risks and Hazards

Cumulative risks and hazards for each exposure scenario were evaluated assuming that all TOCDF sources and all CAMDS sources operate concurrently. As described in Section 3.3.4, sources at TOCDF were evaluated with source-specific, weighted average emission rates, and sources at CAMDS were evaluated with worst-case, source-specific emission rates. Each set of evaluations includes a single COPC emission rate for each source at TOCDF and CAMDS. For each TOCDF source, agent-specific emission rates were first weighted in proportion to the duration of each agent campaign; average COPC emission rates were then calculated for each source. Maximum observed emission rates were used to estimate emissions from CAMDS sources. The TOCDF weighted-average emission rates and CAMDS worst-case emission rates include both detected and non-detected COPCs. Cumulative risks and hazards for each exposure scenario were calculated by summing source-specific risks and hazards based on the receptor location with the highest cumulative cancer risk and the receptor location with the highest cumulative hazard. Presented below are the source-specific cumulative risks and hazards for the subsistence rancher adult and child scenarios, the adult and child resident scenarios, the on-site worker scenario, the adult and child recreationist scenarios, and the fisher adult and child scenarios that exceed the reporting levels.

4.1.4.1 Subsistence Rancher Adult and Child Scenarios

Source-specific cumulative risks and hazards above the reporting levels for the subsistence rancher adult and child scenarios are presented in Table 4-12. The highest risks and hazards correspond to receptor location 28 (Figure 4-1). All sources except the HVAC systems at CAMDS and TOCDF present risk or HI values that exceed reporting levels. Total cumulative risks of 7E-04 for the subsistence rancher adult and 2E-04 for subsistence rancher child scenarios were calculated. Cancer risks above target levels are a result of calculated exposures to the polynuclear aromatic hydrocarbons (PAHs) indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(a)pyrene and EMS. These PAHs and EMS have never been detected in stack emissions from TOCDF or CAMDS. Nor were indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, benzo(a)pyrene or EMS, ever detected in stack emissions from JACADS. The risks from dioxins and benzo(b)fluoranthene were above the reporting level for all sources combined.

Total HI values of 2,400 for the subsistence rancher adult scenario and 4,400 for the subsistence rancher child scenario were calculated. The elevated HI values are attributable to potential emissions of DNOP. DNOP was detected during one run of the CAMDS VX DFS test burn and was not detected during any other emissions test at CAMDS, TOCDF, or JACADS. The calculated hazard from 2,4-dinitrophenol and mustard were above reporting levels for all sources combined. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the subsistence rancher adult and child scenario is presented in Appendix L-1.

4.1.4.2 Adult and Child Resident Scenarios

Source-specific cumulative risks and hazards above the reporting levels for the adult and child resident scenarios are presented in Table 4-13. The highest risks and hazards correspond to receptor location 28. The DFS and MPF units at both CAMDS and TOCDF are the source of risk values that exceed reporting levels. EMS is the only COPC to exceed the cancer reporting level of 1E-05. Total cumulative risks of 1E-05 for the adult resident scenario and 9E-06 for the child resident scenario were calculated. Total HI values of 0.05 for the adult resident scenario and 0.34 for the child resident scenario were calculated. No single COPC exceeds the reporting level for each furnace but when all TOCDF and CAMDS sources are considered, mustard and 2,4-dinitrophenol are above the reporting level. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the adult and child resident scenarios is presented in Appendix L-2

4.1.4.3 On-Site Worker Scenario

Source-specific cumulative risks and hazards above the reporting level for the on-site worker scenario are presented in Table 4-14. The highest risks correspond to receptor location 5, while highest hazards correspond to receptor location 16. The DFS and MPF units at CAMDS pose risks above the reporting level of 1E-06, but below the target level of 1E-05. Two COPCs are mainly responsible for risk. For the DFS at CAMDS, EMS (1E-06) exceeds the reporting level. For the MPF at CAMDS, total chromium risk of 6E-06 and a total HI of 0.14 were calculated. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the on-site worker scenarios is presented in Appendix L-3.

TABLE 4-12 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR SUBSISTENCE RANCHER ADULT AND CHILD SCENARIOS THAT EXCEED THE REPORTING LEVELS						
Source	**Cumulative Cancer Risk (Receptor Location 28)**			**Cumulative Hazard Index (Receptor Location 28)**		
	Adult	**Child**	**COPC > RL [1]**	**Adult**	**Child**	**COPC > DSHW RL [1]**
CAMDS DFS	3E-04	8E-05	EMS, B(a)P, dioxins, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	940	1,700	DNOP, 2,4-Dinitrophenol
CAMDS MPF	2E-04	5E-05	EMS, B(a)P, dioxins, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	480	870	DNOP, 2,4-Dinitrophenol (child only)
TOCDF DFS	9E-05	3E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	410	740	DNOP, 2,4-Dinitrophenol (child only)
TOCDF LIC 1	4E-05	1E-05	EMS, dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene, dioxins	81	150	DNOP
TOCDF MPF	1E-04	3E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene	360	650	DNOP, 2,4-Dinitrophenol (child only)
TOCDF LIC 2	6E-05	2E-05	EMS, B(a)P, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, dioxins	160	290	DNOP
Total Risk or Hazard	**7E-04**	**2E-04**		**2,400**	**4,400**	

Notes:

1	COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025). See Section 4.1 for description of target levels and reporting levels
B(a)P	Benzo(a)pyrene
CAMDS	Chemical Agent Munitions Disposal Facility
COPC	Compound of potential concern
DFS	Deactivation furnace system
DNOP	Di-n-octylphthalate
EMS	Ethyl methanesulfonate
LIC	Liquid incinerator
MPF	Metal parts furnace
NA	Not applicable
RL	Reporting level
TOCDF	Tooele Chemical Agent Disposal Facility

4.1.4.4 SunTen Water Skier Scenario

The total cumulative risks and hazards for the incidental ingestion of water scenario for the Sun Ten water ski lake is well below the reporting levels of 1E-06 for risk and 0.025 for hazard. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for this scenario is presented in Appendix L-4.

4.1.4.5 Rush Lake Adult and Child Recreationist Scenarios

Source-specific cumulative risks and hazards for the adult and child resident scenarios are presented in Table 4-15. No individual sources present risk greater than the reporting level of 1E-06. The risk from all sources combined exceeded the reporting level but not the target level. Total cumulative risk of 4E-06

TABLE 4-13 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR ADULT AND CHILD RESIDENT SCENARIOS THAT EXCEED THE REPORTING LEVELS						
Source	Cumulative Cancer Risk (Receptor Location 28)			Cumulative Hazard Index (Receptor Location 28)		
	Adult	Child	COPC [1]	Adult	Child	COPC [1]
CAMDS DFS	4E-06	3E-06	EMS	<0.025	0.032	No single COPC exceeds reporting level
CAMDS MPF	3E-06	2E-06	EMS	<0.025	<0.025	No single COPC exceeds reporting level
TOCDF DFS	2E-06	1E-06	EMS	<0.025	<0.025	No single COPC exceeds reporting level
TOCDF MPF	3E-06	2E-06	EMS	<0.025	0.026	No single COPC exceeds reporting level
TOCDF LIC 2	2E-06	<1E-06	EMS	<0.025	<0.025	No single COPC exceeds reporting level
Cumulative Risk Or Hazard	**1E-05**	**9E-06**	**NA**	**0.057**	**0.15**	**NA**

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025). See Section 4.1 for description of target levels and reporting levels .

CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
EMS Ethyl methanesulfonate
MPF Metal parts furnace
NA Not applicable
TOCDF Tooele Chemical Agent Disposal Facility

was calculated for the adult recreationist scenario from calculated exposures to dibenz(a,h)anthracene. All sources, except for the HVAC systems at CAMDS and TOCDF, present HI values that exceed the reporting level of 0.025. Total HI values of 11 for the adult and 7.4 for the child scenarios were calculated from calculated exposures to methyl mercury. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the adult and child recreationist scenarios is presented in Appendix L-5.

4.1.4.6 Rainbow Reservoir Fisher Adult and Child Scenarios

Source-specific cumulative hazards for the fisher adult and child scenarios are presented in Table 4-16. No individual sources present risk greater than the reporting level except that the total cumulative risk for the adult fisher scenario is 1E-06 from calculated exposures to dibenz(a,h)anthracene. Risk for the child scenario is less than the reporting level. All sources, except for the HVAC systems at CAMDS and TOCDF, present HI values that exceed the DSHW reporting level of 0.025. Total HI values of 4.9 for the adult and 3.2 for the child scenarios were calculated for exposures to methyl mercury. The IRAP-*h* View output file for the analysis of cumulative risks and hazards for the fisher adult and child scenarios is presented in Appendix L-6.

TABLE 4-14 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR ON-SITE WORKER SCENARIO THAT EXCEED THE REPORTING LEVELS						
Source	**Cumulative Cancer Risk**	**Receptor Location**	**COPC [1]**	**Cumulative HI**	**Receptor Location**	**COPC [1]**
CAMDS DFS	3E-06	5	EMS	<0.025	NA	NA
CAMDS MPF	3E-06	5	Total chromium, modeled as hexavalent chromium	<0.025	NA	NA
TOCDF DFS	<1E-06	NA	NA	0.027	16	No single COPC exceeds reporting level
TOCDF LIC 1	<1E-06	NA	NA	0.029	16	No single COPC exceeds reporting level
TOCDF MPF	<1E-06	NA	NA	0.065	16	Sulfur mustard
Total Risk or Hazard	**6E-06**	NA	NA	**0.14**	NA	NA

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025). See Section 4.1 for description of target levels and reporting levels

CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
HI Hazard index
LIC Liquid incinerator
MPF Metal parts furnace
NA Not applicable
TOCDF Tooele Chemical Agent Disposal Facility

4.1.5 Evaluation of Mutton and Goat's Milk Pathways for the Subsistence Rancher

Concentrations of COPCs in mutton and goat's milk were calculated and compared with concentrations of COPCs in beef and cow's milk to evaluate whether the beef ingestion pathway and cow's milk ingestion pathway are protective for the subsistence rancher adult and child who ingest farm-raised mutton and goat's milk. The agent-specific analysis was performed for the sources at TOCDF based on estimated concentrations of COPCs, which were summed for all sources to calculate the cumulative, or worst-case, concentrations. The comparison used concentrations of DNOP (a systemic non-carcinogenic toxicant) and acenaphthene (a carcinogen) because these bioaccumulative compounds could be present at significant concentrations in meat and milk. The analysis was completed for each agent. Concentrations of COPCs in poultry and pork, two other pathways for the subsistence rancher adult and child scenario, are also compared.

The agent-specific predicted concentrations of COPCs in mutton, beef, chicken, and pork are presented in Table 4-17. The predicted concentrations of COPCs in beef cattle exceed those in mutton, indicating that the beef ingestion pathway is protective for a subsistence rancher who eats farm-raised mutton.

TABLE 4-15 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR THE RECREATIONIST SCENARIO THAT EXCEED THE REPORTING LEVELS						
Source	**Cumulative Cancer Risk**			**Cumulative Hazard Index**		
	Adult	**Child**	**COPC** [1]	**Adult**	**Child**	**COPC** [1]
CAMDS DFS	1E-06	<1E-06	No single COPC exceeds the reporting limit	0.39	0.25	Total mercury (modeled as methyl mercury)
CAMDS MPF	<1E-06	<1E-06	No single COPC exceeds the reporting limit	3.1	2.0	Total mercury (modeled as methyl mercury)
TOCDF BRA	<1E-06	<1E-06	No single COPC exceeds the reporting limit	0.22	0.14	Total mercury (modeled as methyl mercury)
TOCDF DFS	<1E-06	<1E-06	No single COPC exceeds the reporting limit	0.10	0.067	Total mercury (modeled as methyl mercury)
TOCDF MPF	<1E-06	<1E-06	No single COPC exceeds the reporting limit	0.75	0.48	Total mercury (modeled as methyl mercury)
TOCDF LIC 1	<1E-06	<1E-06	No single COPC exceeds the reporting limit	3.4	2.2	Total mercury (modeled as methyl mercury)
TOCDF LIC 2	<1E-06	<1E-06	No single COPC exceeds the reporting limit	3.4	2.2	Total mercury (modeled as methyl mercury)
Cumulative Risk Or Hazard	**4E-06**	**<1E-06**	**Dibenz(a,h)-anthracene**	**11**	**7.4**	Total mercury (modeled as methyl mercury)

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025). See Section 4.1 for description of target levels and reporting levels.

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal Facility
COPC	Compound of potential concern
DFS	Deactivation furnace system
DSHW	Utah Department of Environmental Quality Division of Solid and Hazardous Waste
MPF	Metal parts furnace
NA	Not applicable
TOCDF	Tooele Chemical Agent Disposal Facility

The agent-specific predicted concentrations of COPCs in cow’s and goat’s milk are presented in Table 4-18. The predicted concentrations of COPCs in cow’s milk exceed those in goat’s milk, indicating that the cow’s milk pathway is protective for a subsistence rancher who ingests farm-raised goat milk.

TABLE 4-16 CUMULATIVE CANCER RISKS AND HAZARD INDICES FOR RAINBOW RESERVOIR ADULT AND CHILD SCENARIOS THAT EXCEED THE REPORTING LEVEL						
	Cumulative Cancer Risk			**Cumulative Hazard Index**		
Source	**Adult**	**Child**	**COPC [1]**	**Adult**	**Child**	**COPC [1]**
CAMDS DFS	<1E-06	<1E-06	NA	0.09	0.059	Total mercury (modeled as methyl mercury)
CAMDS MPF	<1E-06	<1E-06	NA	0.74	0.48	Total mercury (modeled as methyl mercury)
TOCDF BRA	<1E-06	<1E-06	NA	0.15	0.09	Total mercury (modeled as methyl mercury)
TOCDF DFS	<1E-06	<1E-06	NA	0.06	0.039	Total mercury (modeled as methyl mercury)
TOCDF MPF	<1E-06	<1E-06	NA	0.39	0.25	Total mercury (modeled as methyl mercury)
TOCDF LIC 1	<1E-06	<1E-06	NA	1.8	1.1	Total mercury (modeled as methyl mercury)
TOCDF LIC 2	<1E-06	<1E-06	NA	1.8	1.1	Total mercury (modeled as methyl mercury)
Cumulative Risk Or Hazard	**1E-06**	**<1E-06**	**Dibenz(a,h)-anthracene**	**4.9**	**3.2**	

Notes:

1 COPC with cancer risk value or hazard quotient that exceeded DSHW reporting level for cancer risk (1E-06) or hazard quotient (0.025). See Section 4.1 for description of target levels and reporting levels

BRA Brine reduction area
CAMDS Chemical Agent Munitions Disposal Facility
COPC Compound of potential concern
DFS Deactivation furnace system
DSHW Utah Department of Environmental Quality Division of Solid and Hazardous Waste
EMS Ethyl methanesulfonate
MPF Metal parts furnace
NA Not applicable
TOCDF Tooele Chemical Agent Disposal Facility

The IRAP-*h* View output files for COPC concentrations in meats and milks, specific to each agent campaign at TOCDF, are presented in Appendices N through P. Note that these results were not recalculated since the April 2002 draft of the HHRA.

4.1.6 Evaluation Of Subsistence Rancher Who Works At DCD

The cumulative risk and hazard (described in Section 4.2) for the subsistence rancher adult and the on-site worker were evaluated to calculate the additional risk and hazard for a subsistence rancher who works at DCD. This evaluation is based on weighted-average emissions from units at TOCDF and worst-case emissions from units at CAMDS. Specifically, the risk was calculated as 7E-04 and the HI was calculated as 2,400 for the subsistence rancher adult. The risk was calculated as 6E-06 and the HI was calculated as 0.14 for the on-site worker. These results indicate that the potential additional risk and hazard associated with working at DCD are negligible.

TABLE 4-17 COMPARISON OF MAXIMUM PREDICTED CONCENTRATIONS OF COPCs IN MUTTON, BEEF, POULTRY, AND PORK						
Agent	**Receptor Location**	**COPC**	**Predicted Concentration [1]**			
			Mutton	**Beef**	**Poultry**	**Pork**
GB	32	DNOP	412	4,805	0.00012	405
		Acenaphthene	3E-09	2E-08	4E-08	1E-08
VX	32	DNOP	270	3,146	0.00008	265
		Acenaphthene	1E-09	9E-09	2E-10	5E-09
Sulfur Mustard	32	DNOP	302	3,516	0.00009	296
		Acenaphthene	3E-09	2E-08	3E-10	1E-08

Notes:

[1] Tissue concentration reported as milligrams per kilogram fresh weight.

COPC Compound of potential concern
DNOP Di-n-octylphthalate
GB Isopropyl methylphosphonofluoridate
VX O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

TABLE 4-18 COMPARISON OF MAXIMUM PREDICTED CONCENTRATIONS OF COPCs IN GOAT'S MILK AND COW'S MILK				
Agent	**Receptor Location**	**COPC**	**Predicted Concentration [1]**	
			Goat's Milk	**Cow's Milk**
GB	32	DNOP	285	2,306
		Acenaphthene	1E-09	1E-08
VX	32	DNOP	186	1,510
		Acenaphthene	5E-10	5E-09
Sulfur Mustard	32	DNOP	208	1,687
		Acenaphthene	1E-09	9E-09

Notes:

[1] Milk concentration reported as milligrams per kilogram fresh weight.

COPC Compound of potential concern
DNOP Di-n-octylphthalate
GB Isopropyl methylphosphonofluoridate
VX O-ethyl-S-[2-diisopropylaminoethyl] methylphosphonothiolate

4.1.7 Evaluation of Acute Inhalation Hazards

Acute inhalation hazard was evaluated for the on-site worker and the adult and child resident scenarios. Each agent campaign was evaluated separately. The receptor locations that corresponded to the highest on-site cumulative HI value and the highest off-site cumulative HI value were identified. Off-site inhalation hazard was evaluated for the resident adult and child scenarios.

For all TOCDF and CAMDS scenarios, acute inhalation hazards were less than the target level of one. For the GB campaign, a maximum HI value of 0.028 was calculated for the on-site worker scenario, and a maximum HI value of 0.004 was calculated for both the adult resident and child resident scenarios. For the VX campaign, a maximum HI value of 0.035 was calculated for the on-site worker scenario, and a maximum HI value of 0.0045 was calculated for both the adult resident and child resident scenarios. For the sulfur mustard campaign, a maximum HI value of 0.06 was calculated for the on-site worker scenario. A maximum HI value of 0.007 was calculated for both the adult resident and child resident scenarios.

The weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the CAMDS sources were also evaluated to estimate cumulative acute inhalation hazards. For this evaluation, a maximum cumulative HI value of 0.093 was calculated for the on-site worker scenario, and a maximum cumulative HI value of 0.015 was calculated for the adult resident and child scenarios.

The Microsoft Access project files for the evaluation of acute inhalation hazard are presented in Appendices Q-1 through Q-8.

4.1.8 Evaluation of Polychlorinated Biphenyls

PCBs are known to be present in the shipping and firing tubes of M55 rockets that are processed in the DFS. No other significant sources of PCBs in the wastes are known. PCBs were evaluated to calculate (1) the HI value for "total PCBs," and (2) the cancer risk for the coplanar, or dioxin-like, PCBs. Agent-specific analyses were completed for each source at TOCDF. Cumulative risk and hazard were also evaluated using the weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the sources at CAMDS. The results of the agent-specific analyses indicate that all source-specific total HI values for PCBs are less than the reporting level of 0.025. In addition, all source-specific cancer risk values for dioxin-like PCBs are less than the reporting level of 1E-06. These analyses were based on the "all COPCs" output discussed in Section 4.1.1. The query of this output also indicated that cumulative risk and hazard for total PCBs and dioxin-like PCBs are less than the reporting levels.

The PCB risk and hazard values are located in the data tables in the database in Appendix A. The PCB risk values are labeled "PCB TEQ" and the hazard values are labeled "Aroclor 1254."

4.1.9 Evaluation of Dioxins

Dioxins are highly toxic compounds that may be formed during the incineration process. Few of the toxic congeners (dioxins and furans with chlorine in the 2,3,7, and 8 positions) were detected at trace concentrations during GB trial burns at the TOCDF. Some of the congeners were detected at similar concentrations in field blanks that suggest the detections reflect contamination of the analytical sample and not dioxins in emissions. The results were not corrected based on the blank results, that is, the HHRA assumed that all dioxins detected in emissions samples were present in stack emissions.

Of the exposure scenarios evaluated, the subsistence rancher has the highest calculated exposure to dioxins because of the potential accumulation of dioxins in homegrown foods such as beef and milk. While risk for the resident scenario is usually about two orders of magnitude less than the risk for the subsistence rancher scenario, dioxin risk for the resident adult and child scenarios were also evaluated to verify this assumption. The Microsoft Access reports for the subsistence rancher and resident scenarios are presented in Appendices R-1 and R-2.

The calculated dioxin risks for all COPCs for the subsistence rancher scenarios were less the target levels for all campaigns at the TOCDF and for CAMDS. For the GB and VX campaigns at TOCDF, no individual source presents dioxin risk that exceeds the reporting level. For the mustard campaign at TOCDF, the dioxin risks for the MPF, LIC-1 and LIC-2 exceed the reporting level. For CAMDS, evaluation of the worst-case emissions indicates dioxin risk exceeds the reporting level for the subsistence rancher adult for the DFS (3E-06) and MPF units (2E-06). These risk values are based on non-detected dioxin congeners. While these risk values exceed the reporting level, they are less than the target level of 1E-05. Approximately fifty percent of the calculated dioxin risks from TOCDF and CAMDS are attributable to CAMDS.

All dioxin risk values for the adult and child resident scenarios are less than the target and reporting level.

4.1.9.1 Evaluation of Proposed Dioxin Slope Factor

In 2000, the Science Advisory Board of the U.S. EPA proposed a new dioxin cancer slope factor of 1.0E+06 (mg/kg BW-day)$^{-1}$, which is 6.67 times higher than the current cancer slope factor. U.S. EPA has not adopted the proposed slope factor. Characterization of dioxin risk for the subsistence rancher adult and child scenarios using the new proposed slope factor indicates the following exceedances:

- For the GB campaign at TOCDF, dioxin risk for all COPCs for the MPF would exceed the reporting level for the subsistence rancher adult scenario.

- For the VX campaign at TOCDF, dioxin risk for all COPCs for LIC 1 and LIC 2 would exceed the reporting level for the subsistence rancher adult scenario.

- For the sulfur mustard campaign at TOCDF, dioxin risk for all COPCs for LIC 1 and LIC 2 would exceed the target level for the subsistence rancher scenario. The dioxin risk for all COPCs for the DFS would exceed target levels.

- Based on weighted-average emission rates for the TOCDF units, dioxin risk for the LIC 1, LIC 2, MPF, and DFS exceed the reporting level for the subsistence rancher adult scenario.

Based on worst-case emission rates for the CAMDS incineration units, the DFS and MPF would present dioxin risk that (1) exceeds the target level of 1E-05 for the subsistence rancher adult scenario, and (2) exceeds the reporting level of 1E-06 for the subsistence rancher child scenario.

4.1.9.2 Noncancer Effects of Dioxins

As discussed in Section 3.5, dioxins were evaluated for cancer effects only in accordance with U.S. EPA (1998) guidance. Comments received on the HHRA protocol (Tetra Tech, 2001) and draft HHRA expressed concerns that hazards may be underestimated because of the lack of a dioxin reference dose for evaluating noncancer effects. The potential for noncancer effects was not evaluated directly but protecting against carcinogenic effects provides a degree of protection for noncarcinogenic effects. That is, assuming that doses equivalent to a cancer risk of 1E-05 are not protective for noncarcinogenic effects, the HHRA methodology would not be protective for only the dose-interval between the lowest adverse effect level for noncarcinogenic effects and the dose equivalent to the target level for carcinogenic effects of 1E-05. For instance, for the TOCDF GB campaign subsistence rancher adult scenario, the calculated cancer risk for dioxins (receptor 23) was 4E-08. The corresponding average daily dose (used for evaluating noncancer effects) is 8E-13 mg/kg-day TCDD TEQs. In this example if the lowest-adverse-effects-level for dioxins is less than 8E-13 mg/kg-day TCDD TEQs, the HHRA methodology would not be protective for dioxin noncancer effects. At the 1E-05 target level for cancer risk, the equivalent average daily dose in TCDD TEQs for the adult rancher is 1.2E-09 mg/kg-day and 1.6E-09 mg/kg-day for the adult resident. These estimated doses are within the average background exposure levels of 1 to 3E-09 mg/kg-day (U.S. EPA, 1998).

Some of the emissions data used to estimate dioxin risks were not congener-specific. When only total homologue data were available (for instance, total pentachlorodibenzo(p)dioxins), the most toxic congener was assumed to comprise the entire homologue group. As future emissions data is collected, congener specific analyses will be conducted that will likely result in a reduction of emission estimates for 2, 3, 7, 8-substituted isomers.

4.1.9.3 Evaluation of Infant Breast Milk Pathway for Dioxins

Potential exposures to nursing infants was evaluated by comparing the calculated intake rate for 2,3,7,8-TCDD TEQ in breast milk to the 6 picograms TEQ per kilogram body weight per day (pg/kg-BW/d) target level selected by the DSHW. The target level is 10 percent of the average background exposure level reported by U.S. EPA (1998). This analysis used the weighted-average emission rates for the sources at TOCDF and the worst-case emission rates for the sources at CAMDS, which assumes that all sources are operating concurrently. The analysis was completed for the subsistence rancher scenario, the resident scenario, and the on-site worker scenario.

The calculated intake rates for 2,3,7,8-TCDD TEQ for each source are less than the target level of 6 pg/kg-BW/d for all scenarios evaluated, indicating dioxin emissions are unlikely to present any significant additional exposure to a nursing infant. The intake rates for the infant of a subsistence rancher scenario ranged from 0.76 pg/kg-BW/d for the DFS at TOCDF to 2.2 pg/kg-BW/d for the DFS at CAMDS. The intake rates for the residential scenario ranged from 2E-05 pg/kg-BW/d for the DFS at TOCDF to 3E-03 pg/kg-BW/d for the MPF at CAMDS. The intake rates for the on-site worker scenario ranged from 8E-06 pg/kg-BW/d for the DFS at TOCDF to 0.03 pg/kg-BW/d for the MPF at CAMDS. As noted above, estimates of dioxin emissions and corresponding exposures are anticipated to decrease for 2, 3, 7, 8-isomers as future emissions tests use a congener-specific analytical method.

The IRAP-*h* View output files for dioxin exposures to the infant of the rancher, resident, and on-site worker scenarios are presented in Appendices M-1 through M-3.

4.1.9.4 Bromine and Sulfur Analogs of Dioxins

No standard analytical method is currently available for brominated, mix bromo-chloro dioxin isomers, or dibenzothiophenes (sulfur analogs of dibenzofurans). Therefore, no emissions data is available from TOCDF, CAMDS, or JACADS for these chemicals. In addition, no U.S. EPA cancer or noncancer toxicity values are available for these chemicals in IRIS or HEAST although limited data suggests that the toxicity of brominated and chlorinated dioxins are similar (Birnbaum and Diliberto, 2002). Bromine is present in emissions based on the detection of brominated volatile organic compounds at CAMDS and TOCDF. The presence of bromine in emissions and trace concentrations of chlorinated dioxins indicates that the formation of brominated dioxins (including mixed chloro- bromo- isomers) is possible. However, the small differences between the sum of all organics compared to the total organic emissions analysis (see Section 4.2.3.2) and the trace amounts of chlorinated dioxins detected suggest that combustion conditions are not favorable for the formation of unidentified dioxin structures including brominated dioxins. Dioxin risks were below target levels when calculated assuming nondetected congeners were present at the detection limit. This procedure is anticipated to overestimate actual risks for the chlorinated congeners. The absence of analytical data and toxicity values for brominated dioxins and sulfur analogs of dioxin is unlikely to result in a substantial underestimate of risk because the risk from chlorinated dioxins was likely overestimated and the concentrations of brominated dioxins is expected to be low.

4.1.10 Evaluation Of Lead

The maximum concentrations of lead in on-site and off-site soil were identified from the cumulative risk and hazard analyses described in Section 4.1.2. The calculated maximum on-site concentration of 23 mg/kg and off-site concentration of 0.4 mg/mg are each well below the 400 mg/kg threshold identified by U.S. EPA, indicating that lead does not pose a hazard. In addition, the maximum concentration of lead in on-site air was estimated to be 0.009 µg/m^3 at receptor location 4, which is adjacent to the south side of the CAMDS facility. The maximum concentration of lead in off-site air was estimated to be 0.001 µg/m^3 at receptor location 44, which is on the northern boundary of DCD. These concentrations are well below the National Ambient Air Quality Standard of 1.5 µg/m^3.

The Microsoft Access project files for the soil and air concentrations are presented in Appendices S-1 and S-2, respectively.

4.2 RISK CHARACTERIZATION FOR COPCS THAT EXCEED TARGET LEVELS

As discussed in Section 4.1, mercury, two PAHS, DNOP, and EMS had calculated risks or hazards above the target levels. The modeling assumptions and the-specific conditions affecting these COPCs and their associated exposure pathways are discussed in the following Section. .

4.2.1 Characterization of Mercury Hazards

The hazard quotient for mercury exceeded the target level of 0.25 for the recreational fisher at Rush Lake and Rainbow Reservoir. The HI target level was exceeded for the TOCDF GB and mustard campaigns, CAMDS, and for the cumulative scenario of both TOCDF and CAMDS operations. The maximum calculated hazard index of eleven was calculated for the Rush Lake recreationist scenario for CAMDS and TOCDF. Calculated mercury hazards were below target levels for all other scenarios.

4.2.1.1 Mercury Source, Fate, and Transport

Although the exact origin is unknown, mercury is known to be present in some of wastes processed at the TOCDF and CAMDS and has been detected in stack emissions. The HHRA evaluates potential exposures to mercuric chloride and methyl mercury but the analyses of stack emissions only measures total mercury. In accordance with U.S. EPA (1998) guidance, defined percentages of the mercury released from the stack are assumed to be elemental mercury and mercuric chloride. Once the mercury leaves the stack, the fate and transport of the two types of mercury are modeled separately with a portion converting via biological processes to a third type, methyl mercury. Methyl mercury is the most toxic form of the three types of mercury. One-hundred percent of the mercury in fish is assumed to be methyl mercury.

For the TOCDF GB campaign, the LICs account for 97 percent of mercury emissions. The pollution abatement systems at TOCDF and CAMDS are ineffective at removing mercury, that is, most of the mercury that is fed to the furnaces will be released to the environment. To determine if test burn waste feeds and corresponding emissions were representative for the wastes to be processed, the TOCDF implemented an extensive sampling program to quantify the mercury (and other metals) in waste feed (for instance, a sample was analyzed every 500 gallons of GB). Results of this program were used to calculate a mass balance for mercury potentially released during the GB campaign (EG&G, 2002a). The mass balance was conducted by estimating the amount of mercury fed to the furnaces with the amount of mercury estimated to be released to the environment in this HHRA as shown in Table 4-22. The results of the mass balance suggest that this HHRA overestimates mercury emissions from the LICs and may underestimate mercury emissions from the MPF. The majority of mercury released from the MPF was predicted to have occurred prior to the year 2000. The increased frequency of testing and implementation of ton container washout procedures significantly reduced the amount of mercury fed to the MPF. The DFS HHRA emissions also overestimated the amount of mercury released but the DFS contribution to the mercury total is small. Overall, the results of the mercury mass balance suggest that the risk assessment overestimates mercury emissions for the GB campaign by a factor of seven.

Based on current information, the GB-campaign wastes are anticipated to have the highest mercury concentrations when compared to VX and mustard wastes. Sampled VX ton containers have lower concentrations of mercury than GB ton containers (EG&G, 2002) and the VX mercury concentrations are measured prior to processing the VX in the LICs. Sampling and analysis of mustard ton containers in storage at DCD were started in 2003 (EG&G 2002b). The preliminary data suggests indicates that mercury concentrations in mustard ton containers may require pretreatment. Emissions data collected at JACADS suggests that mustard mortars have an unidentified source of mercury (PMCD, 1999). Efforts to characterize the mercury contents of VX and mustard munitions are anticipated to continue. Future test burns at TOCDF and CAMDS will reduce some of the uncertainty of predicting mercury emissions for VX and mustard.

Quantifying the amount of mercury released to the environment is the first step in the fate and transport modeling of mercury. A high degree of uncertainty is associated with modeling the fate and transport of mercury compounds. These uncertainties are predominantly associated with the unique site-specific nature and complex fate and transport mechanisms involved with mercury modeling. The U.S. EPA (1998) guidance is being revised to reduce these potential uncertainties. Significant anticipated revisions include dry vapor deposition modeling using mercury-specific deposition velocities and changes to the application of mercury speciations in the fate and transport equations. Although these changes are anticipated in the revised guidance, final values have not been released by the U.S. EPA. In light of the complex nature of mercury modeling, it is unclear how these changes will alter current exposure estimates for emissions from TOCDF and CAMDS.

Environmental monitoring data suggests that the HHRA overestimates the amount of mercury in fish and soil. No mercury has been detected in fish sampled from Rainbow Reservoir (DCD, 2001). Soil sampling results show no accumulation of mercury (Hydrogeologic, 2001). Other sources of environmental releases of mercury in the vicinity of Rush Valley are possible from past gold mining activities. The environmental monitoring for mercury is anticipated to continue as long as the TOCDF operates.

4.2.1.2 Potential Exposure Pathways for Mercury

The potential hazards from mercury exposure are attributable to the consumption of fish contaminated with methyl mercury. The fishing scenario was evaluated as a potential future exposure pathway for Rush Lake and potential current exposure pathway Rainbow Reservoir.

TABLE 4-22 MERCURY MASS BALANCE FOR TOCDF GB CAMPAIGN		
Furnace	**Amount Processed in Furnace (lbs)[1]**	**Amount Emitted in HHRA (lbs)[2]**
Liquid Incinerator 1	4.5	421.5
Liquid Incinerator 2	4.5	421.5
Metal Parts Furnace	124	4.8
Deactivation Furnace	0.0027	5.2
Total	**128**	**853**

Notes:

1 Based on EG&G, 2002
2 Based on HHRA emission rates for 7.67 years

TOCDF Tooele Chemical Agent Disposal Facility
lbs pounds
GB Isopropyl methylphosphonofluoridate

The water level in Rush Lake fluctuates and local residents report that the lake completely evaporates some years (for instance., 2003). The lake is not anticipated to be capable of supporting a sport fishery. The lake was modeled as a conservative surrogate for other reservoirs that support sport fishing such as Vernon and Settlement Canyon reservoirs. Rainbow Reservoir is controlled by DCD. Rainbow Reservoir was stocked with trout and open to the public for fishing for six months of the year but the HHRA assumes year-round fishing. Future public access and fishing at Rainbow Reservoir is uncertain because of cost and security considerations. The HHRA assumes that a receptor gets all of their recreational fish from Rush Lake or Rainbow Reservoir whereas actual fishers may fish at other lakes or streams.

The fish ingestion rate (70.2 g/day) used for consumption of fish from Rush Lake and Rainbow Reservoir is based on subsistence fishing (U.S. EPA, 1998). The ingestion rate is anticipated to overestimate potential fish consumption in Rush Valley but was selected because the ingestion rate is consistent with U.S. EPA (1998), protective, and no fish consumption data was found for the Rush Valley. U.S. EPA (1997) recommends 8 g/day for an average consumption rate and 25 g/day for a 95th percentile estimate (unadjusted for cooking and preparation losses) for recreational freshwater fish consumption. These values are between three and eight times lower than the fish consumption rates used in the HHRA.

Samples of fish, water, and sediment from Rainbow Reservoir have been analyzed for mercury. Mercury has not been detected in fish or accumulating in the water and sediment.

4.2.1.3 Summary of Mercury Hazard Characterization

The calculated hazard indices for mercury compounds exceeded target levels for the consumption of fish. Actual exposures to mercury are judged to likely be less than target levels and are safe because:

1) Mercury has not been detected in fish from Rainbow Reservoir or accumulating in the environment around DCD (Hydrogeologic, 2002).

2) The U.S. EPA (1998) fate and transport modeling for mercury compounds has considerable uncertainties but the methods are intended to more likely overestimate, than underestimate the hazards from mercury.
3) The exposures are overestimated because Rush Lake does not reliably support a sport fishery and Rainbow Reservoir is open for six months a year.
4) The fish consumption rate used in the HHRA was likely an overestimate based on the recommendations of U.S. EPA (1997).

To confirm that mercury is not accumulating to hazardous concentrations in the environment, the concentrations of mercury in wastes to be processed and in environmental samples of soil and fish will continue to be monitored.

4.2.2 Characterization for Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene Risks

The calculated cancer risks for two PAHs exceed the target level of 1E-05 for both the TOCDF and CAMDS: indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene. Consumption of contaminated homegrown beef or mutton, and milk by the subsistence rancher were the source of the exposures that exceeded the target levels.

4.2.2.1 Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene Sources

Indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were not detected in stack emissions at CAMDS, TOCDF, or JACADS in approximately 75 test runs conducted at the three facilities. The calculated cancer risks greater than the target levels were based on analytical detection limits. Existing data on emissions rates for PAHs in stack gas, waste feed materials that contain PAHs, and the chemical reaction kinetics of PAHs were evaluated to assess the likelihood that PAHs might be present in the stack gas at or below the analytical detection limit.

The rate of detected and non-detected PAH emission rates was compared. Only low-molecular weight PAHs (e.g., naphthalene) were detected in stack gases, no high molecular weight PAHs (e.g., indeno[1,2,3-cd]pyrene) were detected. This comparison showed no discernable trend between the various furnaces or agent campaigns, especially for the two PAHs that contributed to the excess risk.

The potential presence of PAHs in the waste feed was analyzed. Although PAHs are not known components of any of the munitions, the MPF may be used to treat agent-contaminated dunnage and other waste materials during closure (for example, motors, bearings, and hydraulic hoses). Any materials in the waste feed contaminated with petroleum-based greases, oils, or lubricants potentially contain PAHs.

Finally, the incinerator reaction kinetics of PAHs were evaluated. PAHs are readily formed in combustion units by either (1) dechlorination of chlorinated aromatic hydrocarbons present in the waste feed or emissions stream (such as dioxins), or (2) the reaction of simple aromatic compounds (benzene or toluene) present in the waste feed or stack gas (U.S. EPA 1998). PAHs are well known as the principal organic components of emissions from all combustion sources. Based on the toxicity and combustion chemistry of PAHs, the absence of these compounds from stack emissions should always be confirmed via stack gas testing (U.S. EPA 1998). PAHs will continue to be target analytes for trial burns at the TOCDF and CAMDS.

4.2.2.2 Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene Fate, Transport, and Exposure Pathways

The calculated risks above target levels were from ingestion of contaminated homegrown beef or mutton, and milk. The homegrown beef and mutton pathways are potentially complete in the Rush Valley because the local people raise cattle and sheep for personal consumption. The homegrown milk pathway is not currently believed to be complete because no one in the Rush Valley is known to raise dairy cows. Rush Valley ranchers do have dairy goats, although based on an informal survey conducted by the DSHW in 1999, no one is known to consume the milk. For the survey, the DSHW searched pastures and interviewed local residents, workers at the TOCDF, government officials, and clergy. The homegrown dairy pathway is considered potentially complete for the future because the pathway could be made complete sometime in the future. The calculated risks for the other evaluated homegrown food pathways (i.e., chicken, pork, produce) were below target levels.

The HHRA assumed that the PAHs indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were emitted from the smokestacks at a concentration equivalent to the analytical detection limits. From the air, the PAHs were modeled to transfer to soil and plants, from the soil and plants to a cow, and from a cow to humans. In accordance with U.S. EPA (1998) no loss to abiotic degradation or metabolism was assumed. However, information in the scientific literature on the toxicodynamics of PAHs indicates that (1) PAHs are readily metabolized, and (2) concentrations of PAHs in the human diet are lower than concentrations predicted by U.S. EPA-recommended procedures. The difference in predicted concentrations for the human diet and observed concentrations is likely a function of not accounting for metabolism and overestimation of concentrations for chemicals with a log K_{ow} greater than six. The log K_{ow} for indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene are greater than six and this phenomena is discussed in greater detail in Section 4.1.7. Not accounting for metabolism results in an overestimation of exposure for the subsistence rancher.

To account for the breakdown of PAHs, Hofelt and others (2001) recommend that a metabolism factor (MF) of 0.01 be applied when calculating concentrations of PAHs in the beef, pork, chicken, egg, or milk pathways in multipathway risk assessments for hazardous waste combustion facilities. PAHs are metabolized primarily by the cytochrome P450 gene family of enzymes, and also can undergo metabolism by a variety of other enzymes to form epoxides, diols, triols, tetrols, phenols, and quinines, as well as conjugation reactions to form glutathioine and sulfuric acid conjugates (Grover 1986 [as discussed in Hofelt and others 2001]). These pathways result in removal of the parent PAH compound, via biliary or urinary excretion or via macromolecular binding of a highly reactive intermediate species, thereby limiting the biotransfer of PAHs through the food chain (Hofelt and others 2001).

Furthermore, a review of scientific literature conducted by Hofelt and others (2001) indicated trends for PAHs in the total human diet that differ from predictions incorporated into the U.S. EPA (1998) model. First, several studies presented in Phillips (1999) (as presented in Hofelt and others 2001) revealed that most of the PAH contributions in the total human diet come from cereals, oils, fats, fruits, and vegetables, while the contributions from meat, fish, milk, and beverages are minor. These ratios differ from PAH concentrations predicted by the U.S. EPA (1998) model, which predicts significantly higher levels in beef and milk than in any other food (Hofelt and others 2001). In addition, analysis of animals in Kuwait exposed to high levels of PAHs as a result of oil fires after the Gulf War showed that there was no significant uptake of carcinogenic PAHs into the food chain (Husain and others 1997 [as presented in Hofelt and others 2001]).

Based on absorption, distribution, metabolism, and excretion (ADME) studies for benzo(a)anthracene, Hofelt and others (2001) first developed a PAH-specific metabolism factor (MF) of 0.001. An uncertainty factor of 10 was applied to the MF to account for interspecies differences in chemical disposition. To confirm the results for benzo(a)anthracene, MFs were calculated for other PAHs where ADME data in published literature are adequate. Calculated MFs for the other PAHs agreed with the value calculated for benzo(a)anthracene. The metabolism factors recommended by Hofelt and others (2001) were not adopted for this HHRA because of uncertainties associated with PAH metabolites. For many PAHs, the metabolites are as, or more toxic than the parent compound.

PAHs were target analytes in soil and vegetation samples collected from the Rush Valley (Hydrogeologic, 2002). Indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene were not detected in these samples that supports the hypothesis that PAHs are not accumulating in the environment. The environmental monitoring is anticipated to continue as long as the TOCDF operates.

4.2.2.3 Summary of Indeno(1,2,3-cd)pyrene and Dibenz(a,h)anthracene Hazard Characterization

Calculated cancer risks from exposure to potentially contaminated homegrown beef or mutton, and milk were greater than target levels. The actual risks from indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene are unlikely to be greater than target levels because:

1) The absence of measurable concentrations of high molecular weight PAHs including indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene in stack emissions,
2) The absence of measurable concentrations of high molecular weight PAHs including indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene in soil samples
3) Not accounting for metabolism in the fate and transport equations, and
4) The tendency for the U.S. EPA (1998) fate and transport model to over predict concentrations of chemicals with a log K_{ow} (octanol-water partition coefficient) greater than six.

However, the presence of indeno(1,2,3-cd)pyrene and dibenz(a,h)anthracene in emissions cannot be definitively discounted because PAHs are readily formed during combustion. Additional data would be helpful in reducing the uncertainties regarding the potential risks from PAHs. The TOCDF and CAMDS should strive for the lowest reliable analytical reporting limits for PAHs. PAHs should continue to be target analytes for trial burns and environmental monitoring.

4.2.3 Characterization of Di(n)octyl Phthalate (DNOP) Hazards

The calculated hazard quotients for the subsistence rancher and child scenarios from DNOP from TOCDF and CAMDS emissions exceed target levels. Consumption of contaminated homegrown beef or mutton, and milk by the subsistence rancher were the source of the exposures that exceed the target levels. The calculated hazards were highest for the VX campaign and for cumulative hazards from the combined operations of the TOCDF and CAMDS.

4.2.3.1 Di(n)octyl Phthalate Sources

Phthalates are a group of chemicals that are used as plasticizers. Many of the emission rates in the HHRA are based on analytical detection limits (that is, the compound was not present above the detection limit) from trial burns at JACADS, CAMDS, and TOCDF; DNOP was detected during one out of approximately 75 runs that comprise the emissions database for the HHRA (detected during the CAMDS DFS VX trial burn). The single detection of DNOP could be from contamination of the sample as opposed to the presence of DNOP in stack emissions (however, DNOP was not detected in the associated blanks).

The potential for phthalates to be in waste feed materials was considered. Phthalates are components of the waste feed for both the MPF and DFS systems but are not likely components of the waste feed for the LIC systems. In the DFS, M55 rockets contain 19.3 pounds of M28 propellant that contains 2.6 percent dimethylphthalate (DMP). Based on the TOCDF DFS feed rates for propellant limits[1], this amount equates to a DMP feed rate of between 16.5 pounds (for GB) and 19 pounds (for VX). In addition to its

[1] DFS propellant feed rates for GB campaign

use as a plasticizer in solid rocket propellants, DMP is used as a plasticizer for nitrocellulose and cellulose acetate, resins, and rubber that are components of waste feed for the MPF. DMP can also be found in lacquers, coating agents, safety glass, and molding powders (Sax and Lewis 1987).

Other phthalates may also be present in the feed to both the MPF and DFS. These compounds are widely used plasticizers and include:

- Diethyl phthalate, used as a plasticizer in solid rocket propellants, as a solvent for nitrocellulose and cellulose acetate, and as a wetting agent
- Di-n-butyl phthalate, used as a plasticizer in solid rocket propellants, as a plasticizer in nitrocellulose lacquers, elastomers, and explosives; in printing inks, as a resin solvent, in paper coatings, and in adhesives
- Butylbenzylphthalate, used as a plasticizer for various resins
- Bis(2-ethylhexyl)phthalate, used as a plasticizer for many resins and elastomers

Furthermore, one phthalate is often substituted for another in a phthalate product, because in most cases the intent is to achieve a specific physical result (such as viscosity at various temperatures), rather than a particular chemical composition. Commercial phthalates can easily contain a percent or more of impurities, for example, bis(2-ethylhexyl)phthalate is a routine contaminant of DNOP, and vice versa.

The chemical reaction kinetics of phthalates were considered. There is no known mechanism for combustion of other chemical compounds to create phthalates as PICs (U.S. EPA 1998). Phthalates and their predecessors are readily combusted compounds as indicated by their flash points of 150 to 225° C. If phthalates were present in the waste, they should be successfully treated (destroyed).

4.2.3.2 Di(n)octyl Phthalate Fate, Transport, and Exposure Pathways

The risk assessment used conservative U.S. EPA-recommended exposure parameters that do not account for all fate processes that could affect the concentration of DNOP in the environment. In particular, the fate and transport algorithms rely on the COPC octanol-water partitioning coefficient (log K_{ow}) value. U.S. EPA (1998) recommends a log K_{ow} value of 9.33 for DNOP. Like any chemical property, the log K_{ow} value depends on the estimation method used to measure the property (Lyman and others 1982), which explains variability of values reported in the literature. For example, Howard and others (1989) report a value of 5.11, while ATSDR (1997) reports a value of 5.22. These values are about 1,000 times lower than the value recommended by U.S. EPA (1998). A lower K_{ow} would result in lower concentrations predicted for DNOP.

The exposure factors U.S. EPA recommends for DNOP also do not account for the degradation of the chemical in the environment. Studies indicate that DNOP may degrade significantly in soils and water (ATSDR 1997, 2000; National Library of Medicine 2001). In a model terrestrial-aquatic ecosystem, DNOP was rapidly biodegraded by inoculated organisms with a half-life of 5 days. Aerobic degradation half-lives range from 1 to 4 weeks in surface waters and from 2 weeks to 1 year in groundwater. Anaerobic biodegradation may also occur but is not expected to contribute significantly. Abiotic degradation may occur through chemical hydrolysis. All of these degradation processes would result in lower concentrations than predicted by the U.S. EPA methods.

DNOP has not been detected in soil or vegetation samples collected from the vicinity of DCD (Hydrogeologic, 2002)

4.2.3.3 Summary of Di(n)octyl Phthalate Hazard Characterization

Calculated hazard quotients from exposure to potentially contaminated homegrown beef or mutton, and milk were greater than target levels. Actual hazards from DNOP are unlikely to be greater than target levels because:

1) With the exception of a single run, DNOP has not been detected in stack emissions.
2) The absence of measurable concentrations of DNOP in soil samples from around DCD.
3) Metabolism and degradation was not accounted for in the fate and transport equations.
4) A conservative octanol-water partition coefficient used in the fate and transport equations.
5) The tendency for the U.S. EPA (1998) fate and transport model to over predict concentrations for chemicals with a log K_{ow} greater than six.

4.2.4 Characterization of Ethyl Methanesulfonate (EMS) Risks

The calculated cancer risk for EMS exceeded the target levels for the drinking water ingestion pathway for the subsistence rancher and resident exposure scenarios.

4.2.4.1 EMS Sources

EMS was never detected during trial and test burns at JACADS, CAMDS, and TOCDF. The existing data on the emission rate of EMS in the stack gas, information on waste feed, and the chemical reaction kinetics of EMS formation were evaluated to asses the likelihood that EMS might be present in the stack gas at or just below the analytical detection limit.

As noted above, EMS has never been detected in stack gas samples. EMS is also not a component of any of the waste feed materials. Therefore, the only remaining potential source of EMS in the stack gas would be as a PIC. Because all of the requisite components for EMS formation (thio groups, ethyl radicals, and methyl radicals) are expected to be present in the combustion system, it is possible—but unlikely—that EMS could be formed as a PIC. It is unlikely to be formed as a PIC because the same components required for formation of EMS would be expected to preferentially form other compounds that require less input of energy. Additionally, EMS is highly soluble in water. Based on the design of the pollution abatement systems at TOCDF and CAMDS, if EMS were generated in the combustion chambers it would be dissolved and removed by the scrubbing solutions. Therefore, EMS is unlikely to be present in the stack gas at concentrations at or just below the detection limits reported.

4.2.4.2 EMS Fate, Transport, and Exposure Pathways

U.S. EPA’s exposure assessment algorithms do not consider the fate of EMS in the environment when exposure is estimated. The following information from the National Library of Medicine’s Hazardous Substances Databank (2001) was evaluated to characterize the fate of EMS in the environment.

Procedures recommended by U.S. EPA do not account for the breakdown of EMS released to the atmosphere. The half-life of EMS vapor that reacts with photochemically generated hydroxyl radicals in the atmosphere has been estimated to be 30 days, based on a reaction rate constant of 5.27E-13 cubic centimeters per molecule-second at 25 ^{o}C and an average hydroxyl radical concentration of 5.0E+05 molecules per cubic centimeter. Reaction with photochemically generated hydroxyl radicals and wet deposition remove EMS from the atmosphere (National Library of Medicine 2001).

EMS is completely soluble in water and rapidly hydrolyzes when it is dissolved in water. The half-life for chemical hydrolysis of EMS has been estimated to be 96 hours based on a measured reaction rate constant of 7.2E-03 liters per hour at 20 ^{o}C. A soil adsorption coefficient (K_{oc}) of 27 was estimated for EMS using a linear regression equation based on its log K_{ow}. This K_{oc} value combined with the complete solubility of EMS in water suggests that there is no significant adsorption of EMS to suspended solids and sediments in water.

EMS is expected to hydrolyze very quickly after it has been deposited to soil. Based on a vapor pressure of 0.328 millimeters of mercury (mm Hg) at 25 ^{o}C, EMS will volatilize rapidly from dry soil.

Therefore, if EMS were actually released in emissions, it would likely breakdown in the soil, air, or water before humans would be exposed via drinking water.

4.2.4.3 Summary of EMS Risk Characterization

The calculated cancer risks for EMS exceeded target levels from exposure via drinking water. EMS was never detected in stack emissions and is unlikely to be present at concentrations less than the detection limit. If EMS were present, it breaks down rapidly in the air, soil, and water. Cancer risks above target levels are not plausible for EMS.

4.3 UNCERTAINTY ANALYSIS

The uncertainty analysis was performed to identify major uncertainties associated with the risk and hazard estimates and to evaluate the effect of the time period of combustion on the estimates of risk and hazard. Major uncertainties associated with the risk estimates were identified for the three main parts of the risk assessment: (1) estimates of emission rates, (2) exposure assessment, and (3) toxicity assessment. The major uncertainties and the potential effects on the risk and hazard estimates are summarized in Table 4-19. The effects of the time period of combustion assumption on the risk and hazard estimates are discussed in Section 4.2.3.

4.3.1 Uncertainties Associated with Emission Rates

As discussed in Section 2.3, it was necessary to extrapolate data from one facility to another to calculate emission rates for some scenarios. Additionally, not all of the COPCs identified during the COPC selection process were quantitatively evaluated during the risk assessment. Finally, several COPCs that have not been detected in samples of stack gas resulted in risk and hazard values that exceeded reporting or target levels based solely on their analytical detection limits. Therefore, various impacts on the uncertainties were introduced into the risk assessment as a result of the emission rates that were evaluated. The uncertainty evaluation includes an evaluation of the use of extrapolated emission rates and the use of total organic emissions data to represent COPCs that were not evaluated.

4.3.1.1 Non-Detected COPCs

COPCs that were not detected in emissions were assumed to be present at the analytical reporting limit from the respective trial or test burn report. Typically, this value is the practical quantitation limit (PQL). The actual concentration of these COPCs may be zero or could be some concentration that is less than the PQL. The HHRA assumed the highest possible concentration for the undetected COPCs and is therefore more likely to overestimate than underestimate their concentration.

TABLE 4-19 MAJOR UNCERTAINTIES IN TOCDF HEALTH RISK ASSESSMENT			
Major Element of the Risk Assessment	**Effect on Cumulative Risk and Hazard Estimates**		
	Underestimate	**Overestimate**	**Unknown**
Emission Rate Estimates			
Evaluation of non-detected COPCs at detection limits		•	
Lack of source-specific trial burn data and the use of surrogate emissions data			•
Potential for unidentified organic chemicals in emissions	•		
Lack of speciated metals emissions rates			•
Exposure Assessment			
Use of U.S. EPA-recommended "default" fate and transport parameter values		•	
Lack of fate and transport values	•		
Use of U.S. EPA recommended "default" exposure parameters (for example, ingestion rates)		•	
General uncertainties and limitations associated with air dispersion modeling (for example, variability and representativeness of air modeling input parameters and meteorological data)			•
Toxicity Assessment			
Evaluate toxicity based on extrapolated values			•
General uncertainties associated with toxicity values		•	
Lack of toxicity values for many compounds	•		

Notes:

COPC Compound of potential concern
TOCDF Tooele Chemical Agent Disposal Facility
U.S. EPA Environmental Protection Agency

4.3.1.2 Extrapolated Emission Rates

Data from trial tests burns at JACADS, TOCDF, and CAMDS were reviewed to select an appropriate method for extrapolating emission rate data from one facility to another for scenarios where trial burn test data are not available. After the available test data was reviewed, it was determined that extrapolating the emission rate data based on both (1) the ratio of actual to permitted agent feed rates, and (2) the ratio of actual to estimated stack gas flow rates, were the most reasonable techniques. Three different types of quality control checks completed to validate the extrapolation process indicated that extrapolated emission rates underestimated empirical stack-specific data by an order of magnitude in some cases and overestimated actual stack-specific data by as much as three to five orders of magnitude in other cases. The HHRA used the maximum emission rate from the two extrapolation methods although little difference was noted between the extrapolated values calculated using either feed and flow rate scaling factors. Based on these results, the overall impact of the extrapolation process overestimates the emission rates of COPCs used to complete the risk assessment and, therefore, overestimates risk.

4.3.1.3 Total Organic Emission Rates

The uncertainty associated with the omission of various organic compounds can be quantified by evaluating the mass of the total organic emissions (TOE) as compared with the mass of the 171 speciated organic COPCs that were used to complete the quantitative risk assessment. Data for TOE mass emission rates are collected during a trial burn test to measure the percentage (mass basis) of the total organic emissions that are quantified using various stack gas sampling and analytical methods that quantitatively identify individual speciated compounds. This ratio of total to speciated mass is known as a "modifier," because it can be used to adjust the emission rate of speciated COPCs to account for the organic mass in the stack gas emissions representing the individual organic compounds that have not been identified.

The values for the TOE modifiers that were calculated for TOCDF and CAMDS range between 0.6 and 7.3. These low TOE modifying values are primarily the result of the conservative approach outlined in the protocol for identifying and quantifying COPC emission rates at their detection limit. That is, only a handful of COPCs were detected during any one trial burn test; the sum of these detected emission rates would be very small compared with the TOE mass, resulting in very high TOE modifiers. However, the sum of the high number of values at the detection limit (and the handful of detected values) is near to, and in some cases exceeds, the measured emission rate of total organics by assuming that the entire target list of COPCs are being emitted at some detection limit value.

TOE modifiers were also calculated using only the sum of the emission rates that were evaluated quantitatively in the risk assessment (detected and non-detected) to assess the impact of the TOE modifier. The values for the TOE modifiers that were calculated ranged between 0.8 and 10.5. The consistency of the modifying factors (0.6 compared with 0.8 and 7.3 compared to 10.5) indicates that the mass of the COPCs evaluated quantitatively represent a large portion of the total organic emissions. Again, the sum of the emission rates for the COPCs evaluated quantitatively is near to, and in some cases exceeds, the measured emission rate of total organics.

Both sets of values indicate that (1) the use of the modifying factors as part of the quantitative risk assessment would have resulted in higher, but overall negligible, differences in the organic emission rates calculated, and (2) the emission rates for speciated organic compounds used to complete the risk assessment represent the majority of the organic mass in the stack gas emissions. The uncertainty associated with non-quantified organics indicates a slight (less than one order of magnitude) underestimation of emissions due to unidentified organic compounds. Assuming that the unidentified organics have the same toxicity on average as the identified organics, the risks and hazards would potentially be underestimated by less than an order of magnitude.

4.3.1.4 Metal Species

For some metals, the chemical form of the metal affects how the metal is transported in the environment. In particular, the chemical form of mercury affects the fate and transport and ultimately, the hazard estimates. Current standard analytical methods are unable to speciate mercury in stack emissions. Predicting mercury fate and transport has a high degree of uncertainty and is discussed in greater detail in Section 4.3.1.1. The direction of potential biases caused by the lack of data on metal species in emissions is unknown.

4.3.2 Uncertainties Associated with Exposure Assessment

The exposure assessment is used to predict how much of a COPC could come into contact with receptors. The exposure assessment begins with the release of COPCs in emissions to ambient air. The COPCs can stay in the air or be deposited on the ground due to partitioning or gravity and wet deposition. The HHRA assumes that receptors contact the COPCs in air, water, soil, and food. The amount of a COPC to which a receptor is exposed is dependent on the amount of COPC in the media and the behavior of the receptor. Uncertainties exist with the air dispersion modeling, fate and transport modeling, and exposure parameters used to estimate exposures.

4.3.3.1 Air Modeling

U.S. EPA (1998) recommended air dispersion modeling was used to predict the concentration in air of the COPCs and the deposition rates at each receptor location. The complexities associated with the air dispersion modeling make determining the direction of any biases difficult. While the impact of the air dispersion modeling uncertainties on the risk and hazard estimates is unknown, the selection of conservative outputs from the modeling help to ensure that risks and hazards were not underestimated. For instance, the HHRA evaluated receptors at the location of the highest predicted concentrations and acute hazards were evaluated using the highest one-hour predicted concentration from five years of meteorological data.

4.3.3.2 Fate and Transport

COPCs were evaluated using U.S. EPA-recommended values for fate and transport parameters. Chemical- and metal-specific fate and transport parameters have been determined for only a limited number of substances. The trends observed for the limited number of tested substances were extrapolated by U.S. EPA to predict the fate and transport of the all COPCs. The fate and transport of the majority of organic COPCs is based on physical constants such as the octanol-water partition coefficient (K_{ow}) and water solubility. Transfer factors used to predict the concentration of organic COPCs in beef and milk are based on the work of Travis and Arms (1988). The U.S. EPA is currently reviewing the predictions from Travis and Arms (1988). The results of this review suggest that the model over predicts for chemicals with a log K_{ow} greater than six and may under predict for chemicals with a log K_{ow} less than two (Birak et al., 2001). The overall effect is that the risk and hazard estimates are more likely to be overestimated than underestimated because the organic chemicals that are typically of most concern for incinerators have higher log K_{ow} values (for instance, dioxins). In addition, the U.S. EPA recommended inputs into the fate and transport equations are conservative. For instance, when a range of K_{ow} values was available in the literature, the K_{ow} recommended by U.S. EPA (1998) results in higher predicted COPC concentrations.

Information to predict the fate and transport of some COPCs is unavailable. The risk and hazard for these chemicals were not calculated. The calculated risks and hazards are potentially underestimated by not including these chemicals. The magnitude of the potential underestimation is anticipated to be small because many of the chemicals lacking fate and transport data are for chemicals that are not typically associated with health risks from incinerators (for instance, TICs). In addition, the results of the total organic emission mass balance discussed in Section 4.2.1.3 supports the hypothesis that the magnitude of the potential underestimation is small.

4.3.3.3 Exposure Parameters

Exposure parameters are the variables used to estimate the intake or dose of COPCs by a receptor. Exposure parameters include variables such as body weight, soil intake rate, inhalation rate, and beef ingestion rate. When available, U.S. EPA (1998) defaults were used with the exception of the amount of time that a worker spends on-site. The amount of time a worker is on site was increased from the default because firemen and paramedics may be on site more frequent than the default assumes. Best professional judgment was used to estimate parameters without defaults such as the amount of water a water skier might ingest. The exposure parameters are intended to result in doses at the upper end of the distribution of exposures. Therefore, the dose estimates should exceed the amount to which most people would actually be exposed.

4.3.3 Uncertainties Associated with Toxicity Assessment

Risk and hazard are estimated by integrating the estimates of exposure with estimates of toxicity. Toxicity values were obtained from the U.S. EPA when available. The U.S. EPA has not published toxicity values for chemical warfare agents, so the HHRA relied on values from U.S. Army and the U.S. Centers for Disease Control (CDC). Uncertainties are associated with chemicals that used a route-to-route extrapolation, U.S. EPA toxicity values, and the lack of toxicity values.

4.3.3.1 CDC Toxicity Values

The CDC proposed new chronic inhalation toxicity values for GB and VX (FR January 8, 2002). The proposed values are lower (more stringent) than the general population limits used in this HHRA. The HHRA uses the current general population limits recommended by the CDC. If the proposed toxicity values are adopted, the HHRA conclusion of no adverse health effects from potential chemical agent exposures will be unchanged. The conclusion will be unchanged because the annual average air concentrations of GB and VX in the HHRA are less than CDC's 2002 proposed general population limits.

4.3.3.2 Route-to-Route Extrapolation

Some of the toxicity values in the HHRA are based on route-to-route extrapolations per U.S. EPA (1998). Route-to-route extrapolations are when a toxicity value for one route of exposure (for instance, ingestion) is extrapolated to a different route (for instance, inhalation). The U.S. EPA (1998) believes that for screening risk assessments, an extrapolated toxicity value is better for screening than no toxicity value.

Route-to-route extrapolations always have uncertainties, but for some chemicals, route-to-route extrapolation is toxicologically inappropriate. Chemicals that are inappropriate for route-to-route extrapolation include chemicals that exert toxicity at the point of entry or are subject to first-pass metabolism in the liver. The extrapolated toxicity values recommended by U.S. EPA (1998) were used for the HHRA with the exception of hexavalent chromium. U.S. EPA (1998) extrapolated an oral slope factor from the inhalation unit risk for hexavalent chromium that is contrary to the assessment in IRIS that does not list hexavalent chromium as an oral carcinogen. Hexavalent chromium was not evaluated as an oral carcinogen in the HHRA. No COPCs with calculated risks and hazards above target levels were based on extrapolated toxicity values.

The effect on the risk and hazard estimates of the route-to-route extrapolations is unknown. However, the potential effect of the lack of toxicity values discussed in Section 4.2.3.3 would be greater if route-to-route extrapolations were not used because the risks and hazards for more chemicals would not have been quantified.

4.3.3.3 U.S. EPA Toxicity Value Uncertainties

U.S. EPA toxicity values have considerable uncertainties. To compensate for these uncertainties, the U.S. EPA applies uncertainty factors to account for inter-species and intra-species differences. The reference doses and reference concentrations are intended to be protective for most people, including sensitive individuals. Cancer potency estimates are intended not to underestimate the cancer potency but may overestimate it. Therefore, for most people the toxicity values used in the HHRA are anticipated to overestimate toxicity.

4.3.3.4 Lack of Toxicity Values

Many chemicals have no toxicity values available. The potential risks and hazards from exposure to these chemicals is not included in the HHRA estimates. Therefore, if exposure to these chemicals is occurring, the HHRA underestimates the risks and hazards. The magnitude of this potential underestimation is unknown but is anticipated to be small. Route-to-route extrapolated toxicity values were used to fill gaps and the total organic emissions analysis (Section 4.2.1.3) suggests that the emissions of most of the organics is included in the risk and hazard estimates.

4.3.4 Sensitivity Analysis on the Time Period of Combustion

A sensitivity analysis was performed to evaluate the effect of changes in the time period of combustion on total risk for all emission sources at TOCDF and CAMDS. The sensitivity analysis was conducted using (1) U.S. EPA-recommended exposure parameters and algorithms for characterizing risk, and (2) source-specific emission rates and air dispersion modeling results. The risk values described below were determined only as part of the sensitivity analysis and **are not representative of actual potential risk impacts associated with operations at DCD**.

Risk estimates were determined using IRAP-h View. The sensitivity analysis was performed on a risk assessment project developed using air dispersion modeling and emission rates from the sulfur mustard trial burn data set evaluated in the HHRA. The risk estimates correspond to the receptor location with the maximum deposition. To evaluate all potential exposure pathways, fish ingestion was added to the default exposure pathways for the subsistence rancher adult. This approach ensures that the effect of the time period of combustion on all exposure pathways was evaluated. Default exposure scenario-specific exposure values (for example, ingestion rates and exposure duration) were used. Risk was then evaluated assuming operating periods of 1, 10, 20, 30, and 40 years. Forty years was set as the maximum time period of combustion to evaluate because it corresponds to the exposure duration for the subsistence rancher adult scenario. Sensitivities associated with the time period of combustion greater than 40 years were not evaluated since the facility is only expected to operate up to 13 years. Tables 4-20 and 4-21 list the results of the sensitivity analysis for cancer risk and non-carcinogenic hazard, respectively. The percent change was calculated as the percent change in risk between the 1-year period of combustion and the 40-year period of combustion (percent increase relative to 1-year time period of combustion).

As shown in Tables 4-20 and 4-21, increases in cancer risks and hazard indices are small when longer operating periods of combustion are assumed. For instance, in Table 4-20 the total risk assuming one year of operation is 7.26E-05 and assuming 40 years of operation increases to 8.49E-05. This 17 percent increase (17 percent of 7.26E-05 added to 7.26E-05 equals 8.49E-05) in risk corresponds to an increase in length of operation from 1 to 40 years, or an increase in length of operation of 3,900 percent. Depending on the individual emission source, percent increases in cancer risk ranged from 6 to 93 percent. In Table 4-21, the total hazard assuming one year of operation is 219 and assuming 40 years of operation increases to 276. This corresponds to a 26 percent increase in hazard for a 3,900 percent increase in operating period. Depending on the individual emission source, percent increase in hazard index ranged from 0 to 52.

The results in Table 4-20 and 4-21 demonstrate that if the there are minor errors in the estimation of campaign durations (for instance, the campaign is five years more or less than estimated), the risk and hazard estimates would not be significantly impacted. The TOCDF was assumed to operate for 13 years and CAMDS for 10 in the HHRA.

TABLE 4-20 EFFECT OF THE TIME PERIOD OF COMBUSTION ON CANCER RISK						
Source	**Time Period of Combustion (years)**					**Percent Change**
	1	**10**	**20**	**30**	**40**	
CAMDS HVAC	2.19E-12	2.66E-12	3.19E-12	3.71-12	4.23E-12	93
CAMDS DFS	3.52E-05	3.68E-05	3.85E-05	4.01E-05	4.15E-05	18
CAMDS MPF	2.02E-05	2.09E-05	2.18E-05	2.26E-05	2.34E-05	16
TOCDF BRA	6.53E-08	6.63E-08	6.74E-08	6.85E-08	6.94E-08	6
TOCDF DFS	1.02E-05	1.05E-05	1.09E-05	1.12E-05	1.15E-05	13
TOCDF LIC 1	1.60E-06	1.75E-06	1.90E-06	2.04E-06	2.13E-06	33
TOCDF MPF	3.19E-06	3.29E-06	3.41E-06	3.53E-06	3.63E-06	14
TOCDF HVAC	3.06E-10	3.36E-10	3.69E-10	4.02E-10	4.36E-10	42
TOCDF LIC 2	2.17E-06	2.32E-06	2.48E-06	2.61E-06	2.71E-06	25
Total Risk	**7.26E-05**	**7.56E-05**	**7.90E-05**	**8.22E-05**	**8.49E-05**	**17**

Notes:

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace system
HVAC	Heating, ventilation, and air conditioning system
LIC	Liquid incinerator
MPF	Metal parts furnace
TOCDF	Tooele Chemical Agent Disposal Facility

TABLE 4-21 THE EFFECT OF TIME PERIOD OF COMBUSTION ON HAZARD						
Source	**Time Period of Combustion (years)**					**Percent Change**
	1	**10**	**20**	**30**	**40**	
CAMDS HVAC	7.51E-06	7.51E-06	7.51E-06	7.51E-06	7.51E-06	0
CAMDS DFS	1.60E-01	1.80E-01	2.02E-01	2.23E-01	2.43E-01	52
CAMDS MPF	7.16E+01	7.18E+01	7.19E+01	7.21E+01	7.22E+01	1
TOCDF BRA	1.15E+02	1.29E+02	1.43E+02	1.57E+02	1.71E+02	49
TOCDF DFS	2.16E+01	2.16E+01	2.16E+01	2.16E+01	2.16E+01	0
TOCDF LIC1	8.33E-01	8.43E-01	8.54E-01	8.64E-01	8.75E-01	5
TOCDF MPF	8.71E+00	8.88E+00	9.07E+00	9.25E+00	9.42E+00	8
TOCDF HVAC	6.27E-04	6.27E-04	6.27E-04	6.27E-04	6.27E-04	0
TOCDF LIC2	8.33E-01	8.43E-01	8.54E-01	8.64E-01	8.75E-01	5
Total Hazard	**2.19E+02**	**2.33E+02**	**2.48E+02**	**2.62E+02**	**2.76E+02**	**26**

Notes:

BRA	Brine reduction area
CAMDS	Chemical Agent Munitions Disposal System
DFS	Deactivation furnace system
HVAC	Heating, ventilation, and air conditioning system
LIC	Liquid incinerator
MPF	Metal parts furnace
TOCDF	Tooele Chemical Agent Disposal Facility

The results in Table 4-20 and 4-21 also demonstrate that if the risks and hazards for the individual TOCDF campaigns were simply summed to estimate the cumulative risk and hazard for all campaigns, overestimations would occur. For instance, assume four campaigns of 10 years each with a calculated cancer risk of 7.56E-05 (Table 4-20) for each 10 years. If the cancer risks for each campaign were summed to estimate the impact from 40 years of operations, the results would be 3.02E-04 (7.56E-05 x 4). However, if the cancer risks are directly calculated by assuming 40 years of operation, the correct result is 8.49E-05 (Table 4-20). One of the contributing factors for the overestimation is that the rancher's exposure duration is unintentionally extended by summing.

The following example demonstrates why the rancher's exposure duration is extended. Assume that the facility starts operating in the year 2000 and has four campaigns of 10 years each, or until 2040. Using the U.S. EPA default exposure factors, the rancher should be exposed for 40 years or until 2040. If the risks from each 10-year campaign are summed, the ranchers exposure duration of 40 years erroneously starts over after each 10 years. By the fourth campaign, the rancher is assumed to be exposed until 2070 (40 years from 2030, the start of the fourth campaign). The rancher would then be assumed to have a total exposure duration of 70 years instead of the U.S. EPA recommended 40 years.

The hazard index is also overestimated if summed for the different campaigns. Assume the same four campaigns of 10 years each. The hazard index assuming 10 years of operation is 233 (Table 4-21). If the hazards for each campaign were summed to estimate the impact from 40 years of operations, the total HI would be 932 (233 x 4). However, if the hazards are calculated assuming 40 years of operation, the correct HI is 276 (Table 4-21). One of the contributing factors for the overestimation is that average daily dose used to calculate the hazard quotient is erroneously added together. For instance, if the average daily dose for the first, second, third, and fourth 10 years is 1 mg/kg-day, the average daily dose for 40 years is 1 mg/kg-day, not 4 mg/kg-day. Using a single weighted average emission rate to calculate the cumulative risks and hazards from all TOCDF campaigns eliminates the potential errors (Section 3.3.4).

U.S. EPA (1998) recommends a default duration of operation of 100 years and the methodology may not be appropriate for incinerators operating for much shorter periods (Tennenbaum, 2000). The results in Tables 4-20 and 4-21 suggest that the U.S. EPA (1998) methodology may overestimate risks for short term operations or underestimate risks for long term operations. The rationale for this observation is that the approximately 85 percent of the risk and hazard for 40 years of operation is attributable to the first year of emissions. Emissions of many COPCs comprise the risks and hazards in Tables 4-20 and 4-21 although only five COPCs are the source of the majority of risk and hazard. Bittner and others (2001) and Desmond and others (2001) showed that the sensitivity of risk and hazard estimates to the time of operation assumption was different for TCDD, mercury, DNOP, and arsenic. The relatively small change in risk over varying durations of combustion is probably the result of the influence of factors on the algorithms used in the risk assessment (for example, site-specific parameters, COPC characteristics, and emission rates (Desmond and others 2001). If other COPCs were the risk-drivers, the U.S. EPA (1998) methods may underestimate risks and hazards from short term operations (Tennebaum, 2000).

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